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APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

REVS. 3289-3607 VOL. 5, NO. 12 DECEMBER 1952

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APPLIED MECHANICS REVIEWS

VOL. 5, NO. 12 MARTIN GOLAND *Editor* DECEMBER 1952

NOTES ON THE EIGHTH INTERNATIONAL CONGRESS ON THEORETICAL AND APPLIED MECHANICS

AUGUST 20 TO 28, 1952, ISTANBUL, TURKEY

D. C. DRUCKER and E. H. LEE

BROWN UNIVERSITY, PROVIDENCE, R. I.[1]

THE GENERAL PROGRAM

ATTENDANCE at the International Congress on Mechanics was a stimulating and pleasurable experience. Seeing new faces and places and renewing acquaintance with many workers in applied mechanics from many lands[2] brought home the diversity and yet the unity of applied science. The great friendliness and sincere interest displayed by the visiting members were, however, completely overshadowed by the truly remarkable hospitality of our Turkish hosts. It is impossible to think of anything additional they could have done in organizing the Congress. There were truly impressive receptions by the Rector of the University of Istanbul, by the Rector of the Technical University of Istanbul, and by the Minister of Public Education. The banquet at the Municipal Casino combined fine food and entertainment. A Sunday boat trip on the Bosphorus enabled members to obtain the best views of the natural beauty of Istanbul and its surroundings. An evening of authentic folk dances and songs presented in an outdoor amphitheatre gave the flavor of an older culture now replaced by a modern one. All these, and there were more, represented but a small part of the work of the Organizing Committee.[3] Buses were always available for transporting members to places to which they wished to go; guides and information personnel were always ready to help. Our thoughtful hosts also left enough free time for individual sightseeing, shopping in the bazaar, visiting mosques and museums, and for all the other fascinating diversions afforded by the cosmopolitan city of Istanbul.

So many people did so much in planning the Congress that it is not possible to mention them all, but it is to Professor Kerim Erim, Chairman of the Organizing Committee, that we were most indebted. Unfortunately the huge burden of work was too much for any man and Professor Erim became ill and was unable to greet the members of the Congress until near the close. Dr. Cahit Arf, Secretary of the Committee, assisted by Dr. Giacomo Saban and all of the Organizing Committee did an excellent job of substituting for Professor Erim.

The opening ceremony took place in the impressive main auditorium of the new Faculty of Science Building of the University. There were brief welcoming and responding speeches and the Congress was officially under way.

THE TECHNICAL PROGRAM

The technical program included seven general lectures, each of an hour's duration, which eminent authorities were invited to present on topics of general current interest in applied mechanics. The remainder of the technical program was subdivided into five sections: (I) Elasticity, plasticity, rheology. (II) Fluid mechanics (aerodynamics, hydrodynamics). (III) Mechanics of solids (ballistics, vibrations, friction, lubrication). (IV) Statistical mechanics, thermodynamics, heat transfer. (V) Mathematics of physics and mechanics, methods of computation.

The sectional programs contained eleven invited sectional addresses, each allotted 45 minutes and consisting of a survey of a particularly active branch of the field. Three were given in each of sections I, II, and V, and one each in sections III and IV. This was a departure from the programs of previous Congresses, and it provided an opportunity for more detailed survey and discussion of particularly active topics than was possible previously. The remainder of the sectional programs consisted of contributed papers, each allotted fifteen minutes for presentation, and five minutes for discussion. There were 335 such papers: 108 in section I, 123 in section II, 37 in section III, 26 in section IV, and

[1] Our attendance at the Congress was sponsored partly by the Office of Naval Research.

[2] French, German, Italian, and English were the official languages. The attendance figures and the Congress membership are as follows, where the number in parenthesis designates the membership and the first number gives those actually present: Australia 2(4), Austria 1(3), Belgium 5(5), Canada 0(1), Czechoslovakia 0(2), Denmark, 4(3), Egypt 4(5), Finland 2(2), France 36(64), Germany 25(33), Greece 3(3), India 2(2), Iran 1(1), Israel 2(4), Italy 12(16), Japan 3(16), Malta 1(1), Mexico 0(1), Netherlands 16(16), Norway 4(5), Pakistan 1(1), Spain 0(2), Sweden 12(15), Switzerland 4(8), Trieste 0(1), Turkey 77(83), United Kingdom 24(36), U.S.A. 90(138), Yugoslavia 3(9).

[3] C. Arf, L. Biran, B. Dizioglu, N. Eraslan, K. Erim, F. S. Giz, W. Gleisberg, N. Gökdogan, M. Inan, S. Kuran, H. Peynircioglu, A. Sokullu, F. Semin, N. Terzioglu, S. M. Uzdilek, A. Yar, F. Yeniçay.

41 in section V. In order to fit this large number into the program time available, it was necessary to run the sectional programs simultaneously, and to have two simultaneous sessions in both sections I and II. Thus, for most of the sectional program, seven simultaneous sessions were in progress. The timing of each talk was specified in the printed program, so that members could plan to hear individual papers in different sections. This arrangement proved extremely satisfactory, and the audiences changed markedly as the sessions proceeded.

The general lectures and sectional addresses will be published in full in the Proceedings of the Congress. Because of the size of the program, brief abstracts only of the contributed papers will appear. Most authors will therefore publish their papers elsewhere.

In the first general lecture, "Social aspects of aeronautics," J. C. Hunsaker presented a fitting opening to the technical program of the Congress in stressing the impact of a branch of applied mechanics on the world in which we live. G. I. Taylor, speaking on "Hydrodynamic theory of detonating explosives," discussed a topic which was extensively developed during the recent World War II and which extends the study of the propagation of discontinuities beyond that of propagation in a single medium. The impact of modern high-speed computational machines on the present and future development of applied mechanics was emphasized by J. von Neumann in his lecture, "Automatic computation and hydrodynamics." R. Courant demonstrated the part played by mathematical analysis in applied mechanics in his lecture, "Reciprocal variational problems and applications to problems of equilibrium." The complex physical phenomena associated with a problem of current active interest in the study of gas dynamics were discussed by A. Kantrowitz in his lecture, "Physical phenomena associated with strong shock waves." W. Tollmien discussed the development of turbulence, a topic of considerable present interest in fluid mechanics, in his lecture, "Über Schwingungen in laminaren Strömungen und die Theorie der Turbulenz." The program of general lectures was completed by A. Lichnerowicz discussing a topic which integrates the various branches of applied mechanics, "Méthodes tensorielles en mécanique."

The section I addresses by H. Geiringer and W. Prager dealt with aspects of the theory of plasticity, and M. Reiner discussed second-order effects in elasticity and hydrodynamics. The contributed papers in this section covered a wide range of topics in the theoretical analysis of stress and strain distributions in elastic, plastic, and viscoelastic bodies, and in problems of experimental stress analysis. Individual topics in these fields which received most attention from authors were the theory of plates and shells, elastic instability, and the solutions of the classical partial differential equations representing elastic stress distributions with infinitesimal displacements. Other sizable groups of papers covering related topics were theoretical and experimental studies in plasticity, and wave propagation and vibration analysis in elastic media. There appeared to be a dearth of papers on the theory of structures, possibly due to the meeting of the International Congress of Bridge and Structural Engineering held in Cambridge, England at about the same time.

In section II, G. Temple discussed a unified method of solution of problems of fluid mechanics in which derivatives in certain directions dominate the motion. J. M. Burgers described the correlation function connected with a nonlinear problem, and F. N. Frenkiel spoke on turbulent diffusion. The contributed papers covered a wide range of both theoretical and experimental topics, ranging in scale from the swimming of microscopic organisms to magneto-hydrodynamics which was initiated in connection with theories of cosmology. Investigations of compressible flow dominated the field, transonic flow attracting the largest number of authors in this group. The theory of turbulence also received considerable attention. In papers on application, work on airfoil theory and experiment was most popular.

The section III address was by A. Signorini, "Quelques recherches récentes de dynamique des solides." The majority of the contributed papers were on vibration analysis, with applications dominating general theory. The applications were mainly drawn from the field of aircraft vibration. Most of the other papers in this section were concerned with friction and lubrication studies.

The program for section IV included a sectional address by M. Roy, "Du combustible à la propulsion." Of the contributed papers, the largest group was concerned with convective heat transfer. General thermodynamic questions and the mathematical analysis of heat-conduction problems provided the majority of the rest of the program.

The inclusion of section V, concerned with mathematical and computational investigations, was another new departure at the Congress. N. Minorsky spoke on the stroboscopic method and its applications. The other two sectional addresses by M. Picone and R. V. Southwell, respectively, were concerned with eigenvalue problems, the former applied to Schrödinger's equation, and the latter to elastic stability problems in which the fundamental mode shape exhibited nodal lines. The contributed papers covered a very wide variety of topics. The largest group of papers in this section was concerned with methods for the solution of differential equations, with the emphasis on partial differential equations. Studies of computing machines represented the next most popular topic.

THE CLOSING CEREMONY

The closing ceremony of the Congress took place in the colorful Ceremonial Hall of Yildiz Palace. Though not yet fully recovered from his illness, Professor Kerim Erim took the chair. Announcing that the next Congress would meet in Brussels in 1956, he ceded the chair to Professor F. H. van den Dungen who expressed the thanks of all members to the Turkish Organizing Committee.

Theoretical and Experimental Methods

(See also Revs. 3304, 3388, 3454, 3500, 3575)

3289. Weissinger, J., Estimation of error for the Adams and Störmer methods (in German), *ZAMM* **32**, 2/3, 62–67, Feb./Mar. 1952.

Formulas exist for estimating the error in the numerical solution of differential equations by extrapolation and interpolation methods. In the derivation of these formulas a linear difference equation is established for the upper bounds of the error. Author shows that, by a more cautious manipulation of the absolute values of the errors, a novel difference equation can be derived, leading to a better estimation formula. He applies this principle to Adam's interpolation and Störmer's extrapolation method for first- and second-order differential equations, respectively.

R. Drenick, USA

3290. Ramamoorthy, C. V., and Soroka, W. W., Resistance wire computing device for solving algebraic equations, *Prod. Engng.* **23**, 2, 134–137, Feb. 1952.

Authors describe in detail a device for solving linear simultaneous equations that consists of 64 potentiometers, the slide wires of which are stretched across a large sheet of wood. The positions of the sliders represent both the coefficients and the variables, the latter having a number of potentiometers corre-

sponding to the number of equations. The solution is obtained by a trial-and-error method. To compare the results given by the computer with the exact results, the response curves of an isolated system of forced vibration were determined for two different values of damping. The agreement is very close.

F. A. Willers, Germany

3291. Swenson, G. W., Jr., Analysis of nonuniform columns and beams by a simple d.c. network analyzer, *J. aero. Sci.* **19,** 4, 273–275, 278, Apr. 1952.

Differential equation of bending is replaced by systems of difference equations. An electrical analog of this system is set up, consisting of a d-c ladder network where displacements are represented by node-pair voltages and moments by branch currents. General problem requires negative resistances which are simulated by subnetworks of resistors and adjustable voltage sources. Solution is obtained by iterative adjustments.

Critical load of stepped column with one transition is determined within 0.5% of analytical value. Method is said to be favorable as regards accuracy, mental effort, and economy.

S. Ekelöf, Sweden

3292. van Wijngaarden, A., Table of the integral $\int_0^1 \exp(-v^{-2} - xv)v^{-p}dv$, *Comput. Dept. Math. Centre, Amsterdam Rep.* R176, 6 pp., 1952.

Five decimal values of the integral have been computed for $p = 0(1)10$, and $x = 0(0.25)3.5(0.5)14.5$. The last decimal is not absolutely reliable. From author's summary

3293. Eshbach, O. W., Handbook of engineering fundamentals, 2nd ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1952. $10.

Second edition of this well-known handbook has been enlarged and many sections revised or rewritten. The most important changes are as follows: Tables of standard structural sizes for aluminum have been added. In mathematics, more emphasis has been placed on determinants, matrixes, and statistics. Section on mechanics of rigid bodies has been enlarged to include gyroscope, generalized coordinates, and Lagrange's equations. A new chapter on experimental stress analysis includes description of various types of strain gages. The chapter on testing of materials has been brought up to date. The most extensive changes are found in the presentation of fluid mechanics, where the original section has been divided into two; one on incompressible fluids, and one on aerodynamics containing new chapters on shock waves, high-speed wind tunnels, propulsion, subsonic, transonic, and supersonic flow, unsteady flow, etc. The sections on engineering thermodynamics and on metallic materials have been revised. One might, perhaps, expect to find in the latter section some information on titanium alloys, but none is given. The concluding section on engineering law has been rewritten.

Reviewer believes the new edition to be a valuable tool for any engineer. T. A. Mortensen, USA

3294. Blanc, C., Differential equations in engineering [Les équations différentielles de la technique] (in French), Neuchatel, Switzerland, Editions du Griffon, 1947, 307 pp. 34.50 sw. frs.

This is a well-written elementary book containing numerous applications to vibration problems. The book is divided into three parts: Ordinary linear differential equations; partial differential equations; and miscellaneous topics.

The four chapters on linear differential equations consider the equations of free, transient, and forced oscillations. In this study, the reader is introduced briefly to the use of matrixes, quadratic forms, Laplace transformations, Fourier series, and integral equations—topics not usually all found in an American elementary text on differential equations.

The second part contains six chapters with headings: D'Alembert's equation and the telegraph equation; Permanent oscillations; The wave equation; Force oscillations; Equation of heat and Poisson's equations.

In the last part there are three short chapters; one on the differential equations of calculus of variation, one on elliptic functions and integrals, and a final one on Bessel functions.

The book is full of excellent illustrative examples drawn from mechanics. In order to include these examples, however, author seems to keep theory to the strict minimum. In spite of this, reviewer feels that it is a good book from which an engineering student (with only slight knowledge of French) can obtain valuable aid. Paul F. Byrd, USA

3295. Mikeladze, Sh. E., New methods of integration of differential equations and their application in problems in the theory of elasticity [Novíe metodí integrirovaniya differentsialnïkh uravneniĭ i ikh prilozheniya k zadacham teorii uprugosti], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1951, 291 pp. 11.50 rubles.

Book gives numerical methods for solution of buckling and vibration problems involving columns and shafts. The principal mathematical interest lies in the first chapter on boundary problems with linear differential equations. The author sets forth here several numerical methods of finding characteristic values, most of them taken from his own writings. These methods employ numerical formulas for integration and differentiation, many of them novel or at least uncommonly used, to construct an equation for the characteristic values of the system. In some cases, the system is converted to an integral equation; in others, formulas for derivatives are used directly. Free use of unbalanced formulas is made. The chapters after the first are devoted to specific applications. The second chapter deals with buckling of columns with various types of end support and lateral restraint. No assumption as to uniformity of the cross section is generally required. The four remaining chapters are much shorter, and deal with stability under loads distributed longitudinally, stability of curved beams, longitudinal vibrations of bars, and transverse vibrations of bars and strings. R. E. Gaskell, USA

3296. Dörr, J., On two integral equations occurring in wing theory (in German), *Ing.-Arch.* **20,** 2, 88–90, 1952.

Author shows by reduction to Cauchy-type integral and direct verification that solution obtained with real or pure imaginary parameter in integral equation also holds for nonzero complex values. The two previously solved cases [AMR **4,** Rev. 3594] are the technically interesting ones. A. Charnes, USA

3297. Gavrilov, N. I., On the stability after Lyapunov of systems of linear differential equations (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **84,** 3, 425–428, May 1952.

Consider the system $dx_i/dt = \sum_{k=1}^{n} P_{ik}(t)x_k$ $(i = 1, 2, \ldots, n)$ ... [1], where the $P_{ik}(t)$ are continuous (in general complex) functions of the real variable t for $t \geq t_0$. Author states (without proof) an effective sufficient criterion for stability in the sense of Lyapunov of the zero solution of [1] for $t \geq t_0$.

Put $u_s = \exp \int_T^t ReP_{ss}(u)du$, $I_{ik} = u_i(t) \int_T^t |P_{ik}(u)|du/u_i(u)$, $i \neq k$, and consider the determinant $|b_{ik}|$ of order n with elements $b_{ii} = 1$, $b_{ik} = -I_{ik}(i \neq k)$. Every element I_{ik} of the i-th row is calculated for one and the same value t_i of t, and the result-

ing determinant is denoted by $D_n(t_1, t_2, \ldots, t_n)$. Determinant criterion of stability: For stability in the sense of Lyapunov of the solution $x_s = 0$ of [1] for $t \geqslant t_0$, it is sufficient that there exists a $T \geqslant t_0$ such that, for any combination of the arguments $t_s \geqslant T$, the following requirements are satisfied: (1) D_n is positive and all of its principal minors are nonnegative; (2) the functions $a_s A_{sk}/D_n (s, k = 1, 2, \ldots, n)$ are bounded, where A_{sk} denotes the algebraic complement of the element (s, k) in D_n.

This criterion, which is of wide application, is illustrated for systems of some particular types, and two theorems which are derived from it show that this criterion determines stability in the presence of positive as well as of zero characteristic numbers. Moreover, it extends some results of Wintner [*Amer. J. Math.* **67,** 417–430, 1945], Weyl [*ibid.* **68,** 7–12, 1946], Yakubovich [*Mat. Sbornik* **28** (70), 1, 217–240, 1951], Khoroshilov [*Prikl. Mat. Mekh.* **15,** 1, 37–54, 1951; *Uchen. Zap. Leningrad. Gosud. Univ. vyp.* 19, 1950], Rapoport [title source, **78,** 6, 1097–1100, 1951], Persidskiĭ [*Izv. Kazansk. Fiz. Mat. Obshch.* 11, 1938], Cesari [*Ann. Scu. norm. sup. Pisa* (2), **9,** 163, 1940], Demidovich [AMR **4,** Rev. 1900], and Basov [title source, **81,** 1, 5–8, 1951].

Eugene Leimanis, Canada

3298. Voelker, D., and Doetsch, G., The two-dimensional Laplace transformation. An introduction to its application for solution of boundary-value problems, with tables of correspondences [Die Zweidimensionale Laplace-Transformation. Eine Einführung in ihre Anwendung zur Lösung von Randwertproblemen nebst Tabellen von Korrespondenzen], Basel, Verlag Birkhäuser, 1950, 259 pp. 39 sw. frs.; bound, 47.85.

G. Doetsch, author of a now classic work on the one-dimensional Laplace transform, has, together with D. Voelker, brought us a book on the two-dimensional Laplace transform. The main object has been to bring together in book form various results on this subject which are scattered throughout the literature, so as to introduce the reader to the application of the two-dimensional transform to boundary-value problems in partial differential equations.

The question which naturally arises is the one concerning the advantage of the two-dimensional Laplace transform over the one-dimensional Laplace transform iterated twice. As authors point out, there is, first, a purely technical advantage in the simplicity of operation. Secondly, the two-dimensional transform gives a deeper insight into the nature of such problems as (a) which boundary conditions can be given so that the associated boundary-value problem has a solution, and (b) whether the boundary conditions can be given independently of one another. Thirdly, a system of two partial differential equations in two unknowns can be reduced to the solution of a system of algebraic equations by use of the two-dimensional transform, whereas the one-dimensional transform only reduces such a system to a system of ordinary differential equations.

Book is divided into two main parts. The first deals with theory and the second is a collection by D. Voelker of tables of correspondences: Correspondences of general operations, correspondences of special functions, and a list of special functions with definitions.

The first chapter concerns the basic properties of the two-dimensional Laplace transform. Since only those two-dimensional transforms are considered which are iterates of the one-dimensional Laplace transform, many proofs of theorems may be obtained directly from the corresponding theorems in the one-dimensional case. Consequently, authors give a full discussion only in those cases where there is a basic departure of the two-dimensional theory from the one-dimensional theory.

The second and third chapters concern the solutions of the classical partial differential equations of mathematical physics. In the fourth chapter, the general partial differential equation of the second order is considered, and the fifth chapter treats systems of partial differential equations with two independent variables. Two more chapters are concerned, respectively, with partial differential equations with three independent variables and with series expansions.

Book is competently written and reviewer believes it will be welcomed by those interested in these problems.

A. Devinatz, USA

3299. Wenzl, F., Iteration method for the calculation of complex zeros of equations (in German), *ZAMM* **32,** 2/3, 85–87, Feb./Mar. 1952.

For solving $F(z) = 0$, set $\varphi(z) \equiv z^m - F(z)$, $\Phi(z) \equiv [z^r \varphi(z)]^{1/(m+r)}$, $z_{\nu+1} = \Phi(z_\nu)$. If $F(\zeta) = 0$, $|\Phi'(\zeta)| < 1$, and z_0 is in some neighborhood of ζ, then $z_\nu \to \zeta$. This process was described by Collatz [*ZAMM* **30,** 97–101, 1950] for algebraic equations. Wenzl remarks that also for F transcendental, for any m there exists an r such that, in fact, $\Phi'(\zeta) = 0$. Likewise, for a pair of equations $F(x, y) = G(x, y) = 0$, he sets $\Phi \equiv x^\mu y^\nu [x^m y^n - F]$, $\Psi = x^\rho y^\sigma [x^r y^s - G]$ and defines an iteration which converges when first partial derivatives of Φ and Ψ are sufficiently small at $x = \xi, y = \eta$ satisfying the equations. The extension to the case of n equations is obvious.

Advantages claimed for this over Newton's method are that the starting point z_0(or x_0, y_0) can be taken farther from ζ (or ξ, η). Moreover, one and the same starting point may lead to each of several solutions by following the different paths in the complex plane corresponding to different roots (there are $m + r$ possible paths from z_0). However, the selection of r for any m involves at least some estimate of $F'(\xi)/\zeta^{m-1}$, and it is not clear to this reviewer that this is easier to arrive at than is a satisfactory starting point z_0 for Newton's method.

A. S. Householder, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Rev. 3310)

3300. Easthope, C. E., The existence of a spin integral in the motion of a rigid body in rolling contact with a rough surface, *Math. Gaz.* **36,** 20–29, 1952.

Following a suggestion made by Milne ["Vectorial mechanics," AMR **3,** Rev. 11], author proves the theorem: In the general motion of a rigid body spinning and in contact with a second surface, which rotates either about a fixed point or about a fixed axis, the motion being such that there is no slipping at the point of contact, while the forces acting on the system are such that they all intersect the line IG (where I is the point of contact and G is the center of gravity of the spinning body), then an integral of the type $\mathbf{i} \cdot \mathbf{H} = \text{const}$ (where $\mathbf{i}$ is a unit vector in the direction of IG and $\mathbf{H}$ the angular momentum about G) exists only if: (a) IG has a fixed direction in space; (b) IG is fixed in the body and coincides with a principal axis of inertia at G; (c) the spinning body is kinetically symmetrical with respect to G and the motion is such that, at any instant, the velocity of the point of contact relative to the second surface is parallel to $d\mathbf{i}/dt$. Applications are made to the case where the moving body is a sphere.

O. Bottema, Holland

3301. Wunderlich, W., On statics of the rope ladder (in German), *Math. Z.* **55,** 13–22, 1951.

An isogram is a skew quadrilateral whose opposite sides are equal [G. T. Bennett, *Proc. Lond. math. Soc.* **13,** 151–173, 1914].

The rope ladder is considered as a series of isogram linkages of constant rung length c and constant rope segment length h. When the weightless ladder, loaded at the ends, is in equilibrium, then the rope segments and the rung at a vertex lie in a plane. If the angle between planes at successive vertexes along the rope is ψ (the rope twist), and the angle between planes at the ends of a rung is γ (the rung twist), Bennett showed that $\sin \psi/h = \sin \gamma/c$. It is shown that each rope takes the form of a polygon with constant rope twists, and that the rung twists are also equal. The force diagram is a double pyramid with equal dihedral angles at lateral edges, and equal dihedral angles at the base edges. The vertexes of the base of this double pyramid lie on an ellipsoid of revolution whose foci are the apexes of the double pyramid. These results are extended to an infinity of rungs to serve as a model for the study of the differential geometry of ruled surfaces of constant pitch. The line of striction is the locus of the midpoints of the rungs. M. Goldberg, USA

3302. Shul′gin, M. F., Theorem on properties of integrals of Chaplígin's dynamical equations (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **84,** 5, 899–902, June 1952.

Continuing the work of two earlier papers [AMR **5,** Revs. 1934 and 1945], author establishes a theorem, analogous to the classical theorem of Poisson, on integrals of Chaplígin's dynamical equations of a nonholonomic conservative system ["Collected Works," **I,** pp. 57–75, Moscow-Leningrad, Gosud. Izd. Tekh.-Teor. Lit., 1948]. The theorem is illustrated by an example of motion of a rigid body parallel to a plane [cf. Chaplígin, ibid., pp. 21–24]. Eugene Leimanis, Canada

3303. Malkin, I. G., On a theorem of stability of motion (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **84,** 5, 877–878, June 1952.

Consider the equations of perturbed motion of the form $dx_i/dt = X_i(t, x_1, \ldots, x_n) + X_i'(t, x_1, \ldots, x_n)$ $(i = 1, 2, \ldots, n)$, [1] where the functions X_i and X_i' vanishing for $x_1 = x_2 = \ldots = x_n = 0$, are defined in the domain $[2]\ t \geq 0, |x_i| \leq H$. Furthermore, assume that the X_i are continuous and periodic in t (or do not contain t at all) and possess continuous first-order partial derivatives with respect to the x_j in the domain [2]. The X_i' are continuous functions of t and x_j in [2], satisfying, with respect to the x_j, the Lipschitz condition or any other conditions which guarantee the existence and uniqueness of the solution of [1]. Then, if the relations $\lim_{t \to \infty} X_i' = 0$ hold uniformly in $|x_i| \leq H$ and the unperturbed motion $x_1 = x_2 = \ldots = x_n = 0$ of the system, obtained from [1] by omitting the X_i' on the right, is asymptotically stable in the sense of Lyapunov, the same is true for the system [1]. Eugene Leimanis, Canada

3304. Gavrilov, N. I., On a method in the stability theory after Lyapunov (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **84,** 4, 657–660, June 1952.

Author outlines a method for determination of stability in the sense of Lyapunov of a linear system with coefficients $P_{ik}(t)$ continuous for $t \geq t_0$. This method (which he calls the method of generalized characteristic equation) is based on a consideration of the characteristic equation [1] $|P_{ik}(t) - \lambda\delta_i^k| = 0$. If the given system is submitted to a linear transformation with variable coefficients $\alpha_{sk}(t)$ of Lyapunov's type (with continuously differentiable bounded coefficients and bounded reciprocal matrix), it assumes the form $y' = (B + C)y$, where C is a Jordan matrix, and the elements b_{ik} of B are linear combinations with bounded coefficients of the derivatives of $\alpha_{pq}(t)$. Moreover, it is assumed that each root of [1] holds its multiplicity. Assume that (a) if $\lambda_s(t)$ is a multiple root of [1], belonging to an elementary divisor of multiplicity $e_s > 1$, there exist $\delta > 0$, $T \geq t_0$ such that $Re\ \lambda_s(t) < -\delta$ for $t \geq T$; further, the elements $b_{ik}(t)$ in the corresponding rows of B are absolutely integrable on $(t_0, +\infty)$ or tend to zero as $t \to +\infty$ for $i \geq k$, but for $i < k$ they are bounded continuous functions of t; (b) if $\lambda_s(t)$ is a simple or a multiple root of [1], but $e_s = 1$, and $Re\ \lambda_s(t) < -\delta$ for $t \geq T$, the assumptions with respect to the $b_{sk}(t)$ remain valid. If, however, the assumption with respect to $Re\ \lambda_s(t)$ fails to be satisfied, there exists a number $N > 0$ such that $\int_{t_0}^{t} Re\ \lambda_s(u)\, du < N$ for $t \geq t_0$, and the elements $b_{sk}(t)$ of the corresponding row are absolutely integrable on $(t_0, +\infty)$. Under these assumptions, the solutions of the given system are stable in the sense of Lyapunov for $t \geq t_0$. It is claimed that this theorem follows from the determinant criterion of stability (see preceding review).

Eugene Leimanis, Canada

3305. Huckert, J., Radii of curvature in slider-crank mechanisms, *Prod. Engng.* **23,** 6, 126–133, June 1952.

Starting with the position vector OP of a point P on a plane curve, author derives for the vector $d\mathrm{OP}^2/d\psi^2$ (ψ is angle between OP and reference direction) an expression which contains the radius of curvature ρ. He evaluates this vector expression for the slider-crank mechanism and its inversions by finding the vector to which it is identical. A semigraphical procedure is required to determine ρ. The method shown permits finding ρ for any point of the link in complex motion in any position of the mechanism.

Reviewer believes that, for practical use, the Bobillier construction for determination of ρ will be preferred because of its simplicity. The Bobillier method [see Reinhold Müller, "Einführung in die theoretische Kinematik," Verlag J. Springer, Berlin, 1932, pp. 22, 23] is purely graphical. Josef Boehm, USA

3306. Kraus, R., Design of straight-line mechanisms. I. Four-bar linkages for four- and six-point straight-line mechanisms with finitely neighboring point positions (in German), *Feinwerktech.* **56,** 6, 175–181, June 1952.

Straight-line mechanisms with given, finitely neighboring coupler point positions along a straight line enable the designer to relate coupler point distances to angles of the driving crank. In this way, by relatively simple means, it is possible to transform rotary motion with a high degree of accuracy into straight-line motion according to prescribed requirements. For instance, there can be correlated equal distances between coupler point positions to equal crank angles.

The article presents several practical examples of straight-line mechanisms with prescribed, finitely adjacent point positions.

From author's summary by Josef Boehm, USA

3307. Lichtwitz, O., Mechanisms for intermittent motion, *Machine Design*, 50 pp., 1952. $1.

Systematic mathematical treatment of kinematic properties (geometry, displacements, velocities, and accelerations) of a particular group of stop mechanisms applicable with considerable versatility to intermittent motion problem considers (1) external and internal Geneva stops and star wheels for parallel axes; (2) intermittent gears for intersecting axes; (3) grooved-cylinder and axial roller-disk combinations for crossed axes. Analogous case is omitted that might have been considered under (3), wherein disk rollers are radial, and grooved driver is of hourglass form.

In cases where evaluations of pertinent functions are tedious, author provides tables of small increments of these, permitting interpolation without significant error. These save designing time and aid in the proper evaluation of a mechanism for a par-

ticular application. Excellent schematic layouts of mechanisms in categories (1), (2), and (3) are given.

Motion diagrams are included; also, recommendations for the scope of usefulness of the respective devices under (1), (2), and (3). Article is an effective working tool for the designer of automatic machinery. Lloyd R. Koenig, USA

3308. Dobrovol'skiĭ, V. V., General theory of mechanisms for describing plane curves (in Russian), *Trudi Sem. teor. Mash. Mekh.* **9**, 36, 11–77, 1950.

Let a range of points be represented by a fixed slotted bar m, a pencil of lines by a slotted crank revolving about a point S. If both slots are of the same width and contain a circular pin free to slide in each, a perspectivity between the range m and the pencil S is mechanized by means of this linkage. Every construction in plane projective geometry can be translated into a mechanism combined of similar linkages if some simple rules are applied. The author does this for the basic contents of this theory (generation of conic sections, etc.). A. W. Wundheiler, USA

Gyroscopics, Governors, Servos

3309. Weiss, H. K., Analysis of a friction damper for clutch-type servomechanisms, *J. aero. Sci.* **18**, 10, 676–682, Oct. 1951.

Paper considers a clutch-type servomechanism with a friction damper consisting of a flywheel coupled to the output shaft by Coulomb friction. Servomechanism drive is by constant torque clutch, and direction of torque depends upon sign of error. Load consists of inertia alone. A finite delay time is assumed in the driving clutch.

Response of servomechanism to constant velocity input is studied on a position-velocity plane. It is demonstrated that a limit cycle composed of four parabolic arcs is obtained for the motion of the output shaft. These limit cycles are shown to have a minimum amplitude. Criteria for obtaining minimum are given.

Reviewer believes paper to be a useful contribution, particularly in design of servomechanisms, where position of a shaft must be determined accurately but small oscillations about mean position are not undesirable. William A. Wolfe, Canada

3310. Loeb, J., Harmonic analysis of nonlinear servomechanisms (in French), *C. R. Acad. Sci. Paris* **233**, 14, 733–735, Oct. 1951.

This brief note completes the results given in a previous one [AMR **5**, Rev. 345]. The stability of the nonlinear dynamical system under consideration is studied by a variational procedure and the stability criterion thus obtained is interpreted graphically. Louis A. Pipes, USA

Vibrations, Balancing

(See also Revs. 3291, 3310, 3324)

3311. Demidovich, B. P., The vibration of bars bent into an arc of a circle (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **5**, 2, 112–132, 1949.

The vibration of circular arcs, treated as a two-dimensional problem (the vibrations in the plane of the arc) was investigated by H. Lamb [*Proc. Lond. math. Soc.* **19**, 365–376, 1888], I. P. Den Hartog [*Phil. Mag.* (7) **5**, 400–408, 1928], F. W. Waltking [*Ing.-Arch.* **5**, 429–449, 1934], and T. Ikebe [*Sci. Papers, Inst. Phys. Chem. Res.* **34**, 679–712, 1938]. All the afore-mentioned investigators assumed that the bar is thin as compared with its length, thus neglecting the rotation of a cross section, and that the central angle subtended by the arc is small. The elongation of the bar was neglected by some and taken into account by the others. The author of this paper neglects the elongation of the bar, neglects the rotation of a cross section, but makes no assumption with regard to the central angle subtended by the arc; therefore, some of his results can be applied to a circular spiral of a very small pitch. Using the conventional equations of motion including the variational principle of Hamilton, author obtains a linear differential equation with constant coefficients of the 6th order. In the absence of external loads, the right member is zero and the equation becomes homogeneous. The solution depends on the boundary conditions, which are given, and the character of the roots of the subsidiary equation. The author discusses at great length the different solutions depending on the different types of roots. He also investigates the vibrations forced by a continuously distributed external load varying with time. This case requires finding the particular integral of the afore-mentioned differential equation. The main contribution is the method of solving the differential equation of motion.

Courtesy of Mathematical Reviews T. Leser, USA

3312. Pisarenko, G. S., The forced normal vibrations of built-in cantilever beams taking account of hysteresis loss (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **5**, 1, 108–132, 1948.

A cantilever beam of uniform rectangular cross section is subjected to a forced vibration by a harmonic oscillation of the support. The material of the beam is assumed to exhibit hysteresis. On the assumption of small deviation from elastic behavior, first- and second-order approximations are determined for the equation of motion of the beam. It is shown that, for all practical purposes, the first approximation yields sufficiently accurate results.

Courtesy of Mathematical Reviews H. I. Ansoff, USA

3313. Bolotin, V. V., On parametrically excited vibrations of elastic arches (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **83**, 4, 537–539, Apr. 1952.

The motion of a two-hinged arch of uniform section is treated under the action of a pulsating load, acting in the plane of the arch and normal to it, at the crown. The critical load at which dynamical instability occurs is found. Experimental results are given which confirm the theory. E. Saibel, USA

3314. Pestel, E., Determination of the effective and reactive power of a simple oscillator with indirect drive (in German), *ZAMM* **32**, 2/3, 88–90, Feb./Mar. 1952.

Forced vibrations of a single mass are considered with the mass attached to a fixed support by means of a single spring and a single damper in parallel. A driving force is applied to the mass through a spring in one case and through a damper in another case, and the equivalent spring constants and damper coefficients are calculated for a prototype such that a new spring and damper connected to the fixed support, with the driving force applied to the mass directly, lead to the same equations. Author points out that equivalent system procedure leads to false results for the reactive power. W. J. Worley, USA

3315. Sretenskiĭ, L. N., Oscillation of a liquid in a moving vessel (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 10, 1483–1494, Oct. 1951.

A rectangular vessel partly filled with a liquid can move in a horizontal direction against a spring force proportional to the deviation from equilibrium. The natural frequencies of this sys-

tem and the form of the free surface of the liquid are calculated on the assumption of small vibrations and the linearized theory of surface waves.

First, the velocity potential of the motion of the liquid relative to the vessel is calculated, and from this, the force exerted by the liquid on the vessel. This force depends in a complicated manner on the frequency of the vibration and is proportional to the deviation of the vessel from equilibrium and can be considered as an additional spring force for the vessel. The system has infinitely many natural frequencies. For a light shallow vessel with a heavy liquid, sometimes a solution is possible in which the vessel moves away in one direction; however, this is not, as the author says, a growing vibration.

An application is given to a pendulum consisting of a light vessel with a heavy liquid, suspended by a light bar.

W. H. Muller, Holland

3316. Storchi, E., Connection between the form of the free water surface and the form of the container in the oscillations of a liquid (in Italian), *Ist. Lombardo Sci. Lett. R. C. Sci. Mat. Nat.* (3) **13** (**82**), 95–112, 1949.

Assuming two-dimensional motion of an inviscid incompressible heavy fluid and the linearized boundary condition for gravity waves, author finds that if the free surface has the form $\zeta(t, x) = \rho'(x)\psi(t)$, then $\psi(t)$ is sinusoidal with frequency ω and the streamlines (including the shape of the container) are given by

$$\omega^2 g^{-1}[\rho(x + iy) + \rho(x - iy)] + i[\rho'(x + iy) - \rho'(x - iy)] = K$$

where K is a real constant and the left-hand side must be real for the chosen function $\rho(x)$ to be possible. A number of special choices of $\rho'(x)$ are treated, giving both new and old results.

J. V. Wehausen, USA

3317. Yushkov, P. P., On the correction of the coefficients obtained in the usual practical harmonic analysis (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **10**, 213–222, 1951.

In an earlier paper [title source, **6**, 197–210, 1950], author obtained approximations a_m and b_m to the Fourier coefficients A_m and B_m for a function $f(x)$ by means of formulas

$$a_m = c_m\alpha_m, \quad b_m = c_m\beta_m \qquad [1]$$

in which α_m and β_m are the coefficients found by the usual process of harmonic analysis with n subdivisions of the period. In the present paper, the idea is extended to express a_m as a linear combination of α's, and b_m as a linear combination of β's. Typical formulas are

$$a_1 = 1.00006\alpha_1 - 0.06585\alpha_i - 0.19901\alpha_9$$
$$a_2 = 1.00079\alpha_2 - 0.02670\alpha_6 - 0.2765\alpha_{10}, \text{ etc.}$$

Tables of the coefficients are supplied for four different cases.

Courtesy of Mathematical Reviews W. E. Milne, USA

3318. Morris, J., and Green, G. S., The yawing vibrations of an aircraft, *Aero. Res. Counc. Lond. Rep. Mem.* 2525, 7 pp., 5 figs., Mar. 1946, published 1952.

Report gives a theoretical method for calculating the natural frequencies and modes of yawing vibration of a complete aircraft. The basic feature of the treatment is the replacement of the continuous-mass system by one consisting of a finite number of discrete masses elastically interconnected. In the course of the analysis, use is made of the deflection-coefficient artifice in the formation of the equations of motion, and the escalator process in their marshalling and numerical solution.

The method has been applied to a single-engined fighter aircraft, for which the results of a resonance test were available. These results appear to be some 40% in excess of their calculated counterparts, and no satisfactory explanation occurs to the authors to account for this incompatibility.

From authors' summary by Henry G. Lew, USA

3319. Housner, G. W., Bending vibrations of a pipe line containing flowing fluid, *J. appl. Mech.* **19**, 2, 205–208, June 1952.

Hamilton's principle is used to establish the governing differential equation of the problem. It is shown that the equation previously obtained by Ashley and Haviland [AMR **4**, Rev. 1461] is incorrect. Natural modes of vibration of system involve all the harmonics of the simply supported pipe with zero fluid velocity. They are coupled by the flow so that all even harmonics are 90 deg out of phase with all the odd harmonics. Reviewer considers Fourier expansion (equation 7) of present paper is incorrect. Vibration equations should read

$$A_{2n-1}[EI(2n-1)^4(\pi/l)^4 - \rho v^2(2n-1)^2(\pi/l)^2 - m\omega_i^2] = (8\rho v\omega_i/l)\sum_k A_{2k}(2n-1)(2k)/[(2n-1)^2 - (2k)^2]$$

$$A_{2k}[EI(2k)^4(\pi/l)^4 - \rho v^2(2k)^2(\pi/l)^2 - m\omega_i^2] = (8\rho v\omega_i/l)\sum_n A_{2n-1}(2k)(2n-1)/[(2n-1)^2 - (2k)^2]$$

These lead to a different frequency equation from that quoted for the restricted case $k = 1$, $n = 1$. Using the equations given above, reviewer endorses author's conclusion that the effect of fluid velocity on fundamental natural frequency is negligible in the case considered. R. W. Traill-Nash, Australia

3320. Malyuzhinets, G. D., The mathematical formulation of the problem of forced harmonic vibrations in an arbitrary region (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **78**, 3, 439–442, May 1951.

Author seeks a unified formulation of wave-propagation problems which shall insure uniqueness for both finite and infinite regions, including the case in which the boundary extends to infinity. He lists briefly the shortcomings of the radiation principle, and of the principle of absorption [cf. A. G. Svešnikov, title source, **73**, 917–920, 1950]. He finds more satisfactory a variant of the latter principle used by V. Fock [*Ann. Physik* (5) **17**, 401–420, 1933], based on analytic continuation from imaginary values of the propagation constant. He goes on to prove a uniqueness theorem for an appropriate Green's function for $\Delta v + \lambda v = 0$, where $\pi/2 < \arg\lambda < 3\pi/2$, which can be deduced simply from a theorem of the author's [title source, **78**, 229–230, 1951], and concludes with miscellaneous remarks.

Courtesy of Mathematical Reviews F. V. Atkinson, Nigeria

Wave Motion, Impact

(See also Revs. 3467, 3572, 3595, 3606)

3321. Satô, Y., Study on surface waves I, *Bull. Earthq. Res. Inst. Tokyo Univ.* **29**, 1, 1–11, Mar. 1951.

In this first part, author studies two points of the theory of elastic waves in the earth. He interprets the characteristic equation of Love waves suggested by the interpretation of wave trains in the Lummer-Gehrcke plate used in spectroscopy, and computes the minimum value of the group velocity and the corresponding phase velocity and wave length. The numerical results are given in two tables and four diagrams.

F. H. van den Dungen, Belgium

3322. Cuénod, M., and Gardel, A., Study of translation waves of small amplitude in case of supply channels of hydroelectric plants (in French), *Bull. tech. Suisse Rom.* **78**, 7, 93–102, Apr. 1952.

Authors' research treats operationally Saint-Venant's surge equation in linearized form. Operational solutions are simplified by reducing operational exponents and characteristic impedance to rational form (i.e., by ignoring wave distortions). Downstream limit conditions are examined corresponding to different linear head-discharge relationships assumed to represent operating characteristics of powerhouse; reflection and transmission coefficients are deduced accordingly.

Authors' operational formulas are algebraized for infinitely long channel, and stability conditions are deduced therefrom; results are that, in presence of friction losses in channel, constant-power operation is found to be unstable and of an expanded aperiodic type with very long time constant.

Finite length channel is then treated, and effect of reflected waves on stability taken into account after proposing use of Nyquist and Leonhard criteria for stability investigation (which, however, are ineffective because the characteristic equation is not algebraic); effect of reflected waves on operating stability is examined in approximate way.

Paper's attack of difficult problem is remarkable, even though mathematical procedure seems to deserve better justification, and results need experimental check.

Giuseppe Evangelisti, Italy

3323. Roseau, M., Reflection of waves in a channel of variable depth (in French), *C. R. Acad. Sci. Paris* **234**, 3, 297–299, Jan. 1952.

The equations of motion-of-gravity waves developed in preceding articles by the author [AMR **5**, Rev. 1009, et al.] are applied to the reflection of waves at a discontinuity in the depth of a channel. The physical description would be much more easily understood if author had included a diagram or two of the waves and the channel.

W. C. Johnson, Jr., USA

3324. Simonyi, K., Calculation of stress and deformation waves in long rods by means of a method used in communication science (in German), *Acta Techn. Hung., Budapest* **1**, 3, 319–362, 1951.

Author develops mathematical analogy between one-dimensional theory of longitudinal waves in rod and theory of ideal alternating-current transmission line by identifying parameters in the system of two first-order partial differential equations of the transmission line with parameters in a similar system for the rod. Various end conditions can be represented in terms of impedance so that mechanical problems are reduced to electrical the problems.

Problems considered include reflection and transmission at interface between rods of different density and elastic modulus, tapered rods and rods with discontinuous diameter, and natural frequencies of such compound rods. Approximation method is proposed for estimating size of cavities or cracks in rod by measuring reflection and transmission properties. Striking of hammer on anvil with or without a plastically deforming object interposed is considered by considerably idealizing the problem.

Lawrence Malvern, USA

3325. Morley, L. S. D., and Plantema, F. J., A discussion of the effect of the flexibility of aircraft during landing impact, *Nat. LuchtLab. Amsterdam Rap.* S.369, 28 pp., 7 figs., Jan. 1952.

A summary and discussion are given of the available theoretical and experimental information relevant to the prediction of the dynamic stresses experienced by large flexible aircraft during landing impacts. Information from 44 references is cited. The paper first considers the physical assumptions of the available theories and discusses such factors as linearization of the problem, the importance of wheel spin-up forces, the nature of the landing-gear forces and accelerations, interaction between the landing gear and the elastic structure, and the manner in which the landing-gear forces or accelerations are applied to the elastic structure. Various theories are briefly summarized and their relative merits and disadvantages are discussed. Finally, available model and full-scale tests are summarized. Authors find that there is at present insufficient evidence to establish the degree of applicability of the available theories to full-scale conditions. They conclude, therefore, that these theories should be used with caution and that there is need for further study of this problem.

Robert F. Smiley, USA

3326. Packham, B. A., The theory of symmetrical gravity waves of finite amplitude. II. The solitary wave, *Proc. roy. Soc. Lond.* (*A*) **213**, 1113, 238–249, June 1952.

In a recent paper [AMR **5**, Rev. 355], T. V. Davies, using the functional method developed by Levi-Civita, but replacing the linear Levi-Civita boundary condition on the free surface by a nonlinear one (i.e., replacing the condition $\partial\theta/\partial\psi = -g\theta/c^2$ by $\partial\theta/\partial\psi = -gl\exp(-3\tau)\sin 3\theta/c^3$), again obtained the solution for symmetrical waves of finite amplitude and determined directly some characteristics of these waves.

In present paper, author, using the same boundary condition written by Davies, determines the solution of the solitary wave and studies some traits of it, i.e., wave velocity, amplitude, and breaking condition at the crest. Result is interesting because Weinstein (1927) proved that, tackling the problem in the same form of Levi-Civita with the linear boundary condition on free surface, no solution was possible with the exception of the trivial one of uniform motion.

Giulio Supino, Italy

Elasticity Theory

(See also Revs. 3350, 3357, 3365, 3436)

3327. Neményi, P. F., and Sáenz, A. W., On the geometry of two-dimensional elastic stress fields, *J. rational Mech. Analysis* **1**, 1, 73–86, 1952.

In this paper, two-dimensional stress systems, which are first of all characterized by the existence of a body force potential $M(x, y)$ such that $f = \nabla M$, are considered. The two-dimensional stress field is referred to as an M-system if f satisfies one of the following three sets of conditions: (a) The stress is plane, f is solenoidal, i.e., $\nabla^2 M = 0$; (b) the strain is plane, f is solenoidal, i.e., $\nabla^2 M = 0$; (c) the strain is plane, the material incompressible, hence Poisson's $\nu = 1/2$.

Using complex variable methods, the following theorems are then proved for simply connected regions. (1) Any two-dimensional elastic field of M-type can be obtained by superposition of two isometric stress systems, one of which is harmonic in the sense of Föppl, i.e., whose first invariant $2S = \sigma_x + \sigma_y = \sigma_1 + \sigma_2$ is everywhere zero, and the other harmonic in the sense of Pólya, i.e., systems for which each component of the stress tensor is harmonic. (2) Let Ω and Ω^*, defined by the equations

$$\Omega = \bar{z}f(z) + g(z) = We^{-2i\Theta},\ \Omega^* = \bar{z}f^*(z) + g^*(z) = W^*e^{-2i\Theta^*}$$

where W and W^* are real, be the conjugate stress deviators corresponding to a pair of M-systems, and let $f(z), g(z), f^*(z), g^*(z)$ be all identically different from zero. Then the stress trajectories

corresponding to Ω and Ω^* are one another's reflection across the x-axis, that is, $\Theta^* = -\Theta$ only if both f/g and f^*/g^*, if substituted for u, satisfy identically the equation

$$(qz^2 + \bar{p}z + \gamma)u^2 - (\bar{r}z^2 + \beta z + p)u + (\alpha z^2 + rz + \bar{q}) = 0$$

where (α, β, γ) are real and (p, q, r) complex numbers, and where at least one of the quantities (α, q, r) and one of (γ, p, q) are different from zero. (3) The knowledge of $W(x, y)$ and of the stress trajectories of an M-system in a simply connected domain R determines the corresponding stress components σ_x, σ_y, τ_{xy} to within a single arbitrary constant. This last theorem leads to the final result: The family of plane elastic stress fields corresponding to a given set of stress trajectories is a family having between two and five parameters. The complete proof of this result is reserved for a later paper.

Courtesy of Mathematical Reviews R. M. Morris, Wales

3328. Angles d'Auriac, P., On a geometric form of equilibrium conditions of deformable surfaces (in French), *C. R. Acad. Sci. Paris* **234,** 3, 294–295, Jan. 1952.

Let a variable interior point M of a simply connected elastic surface be connected to a fixed point A of the boundary by a curve AM; set at M the initial points of the vectors of resultant force and moment exerted by one side of the curve upon the other; let μ and ν be the termini of these vectors. Then μ and ν are independent of the path AM, and as M traverses S, μ and ν traverse image surfaces Σ and Σ_1. For the case of an infinitely flexible surface, the author states that the tangent planes at corresponding points of S and Σ are parallel; that there exists a net of orthogonal isostatic curves on S; and that Σ is a possible equilibrium configuration of S. Explanations, proofs, and further results are to appear elsewhere. C. Truesdell, USA

3329. Amyerich, G., On the expression in curvilinear coordinates of stresses and displacements in plane elasticity (in Italian), *R. C. Semin. Fac. Sci. Univ. Cagliari* **20,** 175–183, 1950.

Author solves the following questions in plane elasticity: (1) He expresses the stresses in terms of Airy's stress function U in orthogonal curvilinear coordinates; (2) he shows how to calculate the displacements from a knowledge of U and its biharmonic conjugate. He then points out how this work can be employed to obtain solutions of plane-elasticity problems by conformal-mapping methods, by an improvement of the techniques developed by Muskhelishvili [see, e.g., *Math. Ann.* **107,** 282–312, 1932]. Aside from the methods employed to derive the results, there is little new in this paper. A. W. Sáenz, USA

3330. Föppl, O., Analysis and synthesis of the state of bending stress $\sigma_0\sigma_s = f(x, y, z)$ (in German), *Mitt. Wöhler Inst.* no. 46, 53 pp., 1951.

Author summarizes and further discusses his previous work [AMR **5,** Revs. 47, 363] criticizing the validity of the linear superposition principle in the classical theory of elasticity. While not clearly stated so, his objections are based essentially on the remark that the strains associated with the component stress distributions in such a principle cannot be superimposed. It is well known, however, and experimentally established that, for sufficiently small deformations, nonlinear terms in strain-displacement relations can be neglected, and then the superposition principle of strains holds. It is also well known that, for large deflections, the linear superposition of strains is not valid, and for such cases author's criticism is valid but not new. Reviewer believes that the only new element in author's work is the introduction of a corrective stress distribution, which he calls state-of-bending stress $\sigma_0\sigma_s$, that can compensate for the failure of the superposition principle of strains, if the displacements are so large that the linear theory cannot be applied. As in his previous work, however, author has not shown that this is feasible and leads to practical results, although he promises in the present paper that one of his students will do so in a doctoral dissertation. The establishment of such a procedure and its experimental verification are essential and should be presented before author's arguments acquire practical research value. G. A. Zizicas, USA

3331. Melan, E., Stresses in ceilings with panel heating (in German), *Publ. int. Assn. Bridge struct. Engng.* **11,** 337–345, 1951.

The stresses occurring in a concrete ceiling with panel heating are examined in accordance with the theory of heat stresses in elastic bodies. In the case of clamped edges, comparatively simple expressions are obtained; for free edges, the maximum moments occurring for different ratios of the side lengths of the slabs can be obtained at once from a table.

From author's summary by M. L. Williams, Jr., USA

3332. Salzmann, F., Thermal stresses and deformations in an elastic body with a steady, two-dimensional heat flow (in German), *ZAMP* **3,** 2, 129–148, Mar. 1952.

A rediscovery of the reduction of the thermal stress to dislocational stress. The earlier papers are by N. Muskhelishvili [*Bull. Elec. tech. Inst.* (St. Petersburg) **13,** p. 23, 1916] and M. Biot [*J. appl. Mech.* (*Trans. ASME*), p. A-41, 1935].

J. N. Goodier, USA

3333. Rabotnov, Yu. N., Stress and deformation in cyclic loading (in Russian), *Prikl. Mat. Mekh.* **16,** 1, 121–122, Jan./Feb. 1952.

Experimental data indicate that the distribution of stresses in a vibrating body differs from that due to static loading in similar conditions; the concentration of stresses in the former case is lower. This paper attempts to supply the theoretical explanation. Tensor notation is used throughout. The assumptions are as follows: (1) The stresses and the deformations obey the theory of small elastoplastic deformations; (2) the stress-strain relation is nearly linear; (3) the ratio of the scattered energy to the total elastic energy is small; (4) the area of the loop of the hysteresis is independent of the state of stress. Using these assumptions, author derives expressions for stresses and strains. These consist of two parts. The first part is in the phase with the exterior forces and can be computed from the conventional elasticity formula. The second part is off the phase by 90° and looks like the expression for thermal stresses, but it is combined with the first part differently than it is in the thermal problems. The expression for scattered work is used to determine the damping properties of the material. An example of a beam bent cyclically by exterior forces illustrates the application of the theory.

Courtesy of Mathematical Reviews T. Leser, USA

3334. Anderson, O. L., Conditions for the derivation of the stress deviator tensor, *Amer. J. Phys.* **20,** 236–242, 1952.

Author states in his abstract, "The decomposition of the stress tensor into the spherical stress tensor and the stress deviator found in theories of plasticity is shown to depend upon the postulate that the stress tensor is the tensor sum of two physically independent stress constituents. The decomposition is derived by two different methods, the first method based on energy arguments, and the second method based on cause and effect arguments." The arguments presented do not convince the reviewer that a purely mathematical operation requires any justification or, much less,

that it is subject to any "conditions." Furthermore, even the simplest experiments in plastic straining show the need for the third stress invariant dismissed so lightly by the author. Slightly more elaborate experiments require consideration of more elaborate invariants of stress and strain. The elastic energy and simple linear cause-and-effect relations do not seem especially relevant to anything but linear elasticity.

D. C. Drucker, USA

3335. Rozovskiĭ, M. I., The flow curve and elastic aftereffect (in Russian), *Zh. tekh. Fiz.* **22,** 5, 880–882, May 1952.

Author applies well-known theory of linearly superposable aftereffects to the two special cases in which (1) the stress or (2) the strain increases at constant rate for times $t > 0$. For special forms of the aftereffect functions, the integrals are expressed as incomplete gamma functions or series. No numerical values are calculated or experimental data fitted, though several experimental papers are cited as sources of the aftereffect formulas treated. Wm. Fuller Brown, Jr., USA

3336. Kondo, K., The geometry of the perfect tension field. III, *J. Japan Soc. appl. Mech.* **4,** 24, 101–104, Oct. 1951.

The author continues his researches on stress fields in which two principal stresses vanish at each point [AMR **4,** Revs. 599, 2391]. He now considers some of the ruled surfaces tangent to such fields.

C. Truesdell, USA

3337. Prentis, J. M., On the compression of a cube between rigid rough plates, *Quart. J. Mech. appl. Math.* **5,** part 2, 253–256, June 1952.

Author uses method of Synge and Prager [*Quart. J. appl. Math.* **5,** 241–269, 1947] to establish bounds for Young's modulus by compressing a cube of elastic material between rigid plates which are sufficiently rough to prevent relative lateral movement. Poisson's ratio is taken as $1/3$. The "associated" and "complementary" states are constructed by choosing functions which satisfy the appropriate conditions. Employing these selected functions, the inequalities of Synge and Prager lead to a Young's modulus which is 94.2% of the apparent modulus of mean stress and mean strain. Edelman [AMR **3,** Rev. 2615] found 94.7% when compressing a circular cylindrical block between two plates. D. L. Holl, USA

Experimental Stress Analysis

(See also Rev. 3350)

3338. Krisement, O., Experimental stress analysis with resistance strain gages (in German), *Arch. Eisenhüttenw.* **23,** 3/4, 157–161, Mar./Apr. 1952.

Expository article dealing with rapid calculation of stress from strain data obtained with strain gages. Influence of transverse gage sensitivity is considered. Sverker Sjöström, Sweden

3339. Trott, J. J., An electronic device for measuring small transient displacements, *J. sci. Instrum.* **29,** 7, 212–214, July 1952.

A description is given of an electronic device for measuring small transient displacements of magnitude down to 10μ in., the apparatus being suitable for use whenever it is possible for part of the equipment to be mounted on a stable support and a small, lightweight steel plate to be attached to the moving part. The apparatus was devised initially for measuring the relative and absolute movements of concrete road slabs under the wheel loads of vehicles. The device is based upon the variation of output of a high-frequency oscillator caused by the movement of a metal disk near its tuning coil, and the output is linear over the range up to 0.10 in. The equipment is used with a persistent cathode-ray tube for visual estimation of displacements, and with cathode-ray recording gear when permanent photographic records of the displacements are needed. From author's summary

3340. Durelli, A. J., and Ōkubo, S., Use of "stresscoat" in stress analysis requiring brittle coating of increased sensitivity (in Spanish), *Cienc. y Técn.* **119,** 601, 1–8, July 1952.

See AMR **5,** Rev. 1975.

3341. Tucker, C. W., Jr., and Anderson, H. V., X-ray stress measurements, *Proc. Soc. exp. Stress Anal.* **9,** 2, 67–74, 1952.

Authors give a general review of stress measurement by x rays. Formula is given for calculation of subsurface stresses by removal of metal by etching. If article gives actual state of technique, no progress has been made since 1938. Authors only mention the possibility of use of Geiger counter. Applications of method are taken from other authors. Reviewer draws attention to the fact that direction of strain measurement is not direction of incident x ray, but direction of bisectrix between incident ray and reflection. Focusing is not so simple—especially when inclined incident ray is used—as authors state.

W. Soete, Belgium

3342. Favre, H., The photoelasticity laboratory of the Federal Polytechnic School in Zürich (in Spanish), *Inst. tecn. Constr. Cem. Publ.* no. 112, 3–22, July 1951.

Purpose of this paper is to give a general survey of Favre's purely optical method. A summary, mostly descriptive, of the optical phenomenon upon which the method is based is presented. The equipment used is also described. The illustrations for practical applications of the method are taken from the research carried on by author and his assistants. The main advantage of this method is that a complete stress analysis is obtained without further calculations or experiments. According to reviewer's experience, in spite of the rather laborious procedure of point-by-point readings, in many two-dimensional problems a skilled experimenter can obtain a fast and accurate solution. This makes Favre's method very attractive and deserving of further development. C. A. Sciammarella, Argentina

3343. Favre, H., The purely optical method and its applications in plane elasticity and plates subjected to flexure (in Spanish), *Inst. tecn. Constr. Cem. Publ.* no. 112, 23–51, July 1952.

Following a brief review of the previous paper, author gives more examples of specific problems that have been studied with the purely optical method. He also presents the extension of his method to the plate analysis [original paper, *Schweiz. Bauztg.* **13,** May 20, 1950].

Author derives a set of equations for principal bending moments of sandwich plates, formed by two photoelastic materials, similar to those he uses in two-dimensional photoelasticity. Therefore, the same experimental procedure employed in the two-dimensional cases can be applied to obtain the principal bending moments and trajectories in plates subjected to flexure.

Illustration of the practical use of the developed theory is given. The case of a square plate, centrally loaded and supported at three points, is studied. The plate is formed by two layers, glass and Allyte, carefully cemented together. Results show that the degree of accuracy of the method is satisfactory.

In reviewer's opinion, this is a useful and successful broadening

of the field of use of Favre's method. However, it has some limitations: (1) The materials of model and prototype must have the same Poisson ratio. This is not very important, because a difference in Poisson ratio will probably have little effect. (2) The interpretation of interferometer readings presents some difficulties in the points where the elastic surface has great slope. (3) The main obstacle is encountered in the loading device. It must satisfy the requirements of the measuring procedure, it being necessary to make the observations in the same direction from which the forces are applied. C. A. Sciammarella, Argentina

3344. D'Arga e Lima, J., Measurement of deformations with mechanical extensometers (in Portuguese), *Minist. Obras Publ., Lab. Engen. civ. Lisboa Publ.* no. 19, 36 pp., 1951.

This publication contains description and main characteristics of the most important types of mechanical extensometers. Chapters cover: Introduction with historical review; extensometers with small amplification, their properties, accessories, and use, with special consideration of deflectometers; extensometers with great amplification (Huggenberger, Johannson); optical extensometers; interferometers; extensometers with electronic amplification; pneumatic extensometers, recording extensometers (Amsler, Riehle-Comins, Templin). The study includes basic principles and operation, with special emphasis for use in laboratories and in structures. J. J. Polivka, USA

3345. Weimer, A., Precision extensometers (in German), *Feingerätetechnik* **1**, 1, 19–23, Apr. 1952.

Extensometers, or strain gages, which involve mechanical, optical, or electrical principles—or their combinations—are described. Electrical gages are further divided into those which operate by changes of resistance inductance, or capacitance. Short discussions and simplified drawings are given, illustrating the operation of some of these types. These include rotating mirror systems; lever arrangements to amplify motions which may then be detected by unbalance of inductive circuits; electrical resistance changes involving chang. of electrode positions in an electrolyte; a photoelectric device in which a movable slit is placed near the focal plane containing an image of a small light source, and others. A table is given which indicates roughly the sensitivity that can be expected from some of these pickup types.
I. Vigness, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 3333, 3361, 3372, 3380)

3346. Craemer, H., Deformations of ideal-plastic statically determined beams (in German), *Ing.-Arch.* **20**, 2, 126–128, 1952.

An elastoplastic study of a simply supported, rectangular beam loaded with two equal, concentrated loads shows that the solutions presented in some books on plasticity are erroneous. The assumptions of a sudden transition from an elastic to a plastic state, of the dependence of the beam deformations only on the deformations of the most highly stressed section, and of letting all of the section moment to operate on the elastic core are scrutinized. The conclusions are applied to I-beams, and the resulting incongruities due to the above assumptions are pointed out.
Dimitri Kececioglu, USA

3347. Phillips, A., Bending with axial force of curved bars in plasticity, *J. appl. Mech.* **19**, 3, 327–330, Sept. 1952.

The problem of symmetrical pure bending with axial force of a curved bar in plasticity is considered. A method is given for finding the axial load and bending moment which produce a given strain distribution. This method is based upon approximating the stress-strain curves by means of broken lines. By increasing the number of sides of these broken lines it is possible to solve the problem with as high accuracy as is desired.
From author's summary by W. L. Esmeijer, Holland

3348. Bozhenko, A. S., The bending (according to Saint Venant) of a beam with a cross section composed of rectangular pieces subject to a normal force in the plane of symmetry (in Russian), *Inzhener. Sbornik Akad Nauk SSSR* **5**, 1, 93–107, 1948.

Author considers a beam with a constant cross section as in the title, one end fixed, the other end loaded by a constant force which acts in the plane of symmetry, normal to the axis of the beam. He treats the problem as a three-dimensional one and studies the following cross sections: (1) Tee; (2) I, with different upper and lower shelves; (3) channel; (4) a cross with two axes of symmetry. In all cases the corners are sharp, hence the results cannot be used in practice. The expressions for the shearing stresses are obtained from the conventional equations of the theory of elasticity, the boundary conditions, and the conditions at the junctions of the two rectangular regions of the cross section. In each case, the stress function contains a sum of harmonic polynomials of third degree or less, plus a Fourier series. The determination of the coefficients of the Fourier series seems to be very complicated. Author compares a few numerical examples solved as two-dimensional problems with his results. The shearing stresses in the latter case are by 2% or less lower.
Courtesy of Mathematical Reviews T. Leser, USA

3349. Korenev, B. G., On the computation of beams and plates, taking account of plastic deformation (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **5**, 1, 58–61, 1948.

Consider a beam on an elastic foundation subjected to two concentrated transverse forces. Further, let one or both of the forces exceed the yield limit. If the beam exhibits no hardening, the value of the moment at the plastic sections will remain constant at the yield value. The elastic solution of the problem must now be modified to satisfy this condition. This is done by adding a solution of the homogeneous beam equation which satisfies the boundary condition and produces a discontinuity in the slope of the beam at the plastic sections. The same method is applied to a brittle beam which develops a transverse crack at one of the loaded points. The method is also applied to a plate on an elastic foundation with a circular loading pattern.
Courtesy of Mathematical Reviews H. I. Ansoff, USA

3350. Hopkins, I. L., Principal strains in cable sheaths and other buckled surfaces, *Bell Syst. tech. J.* **31**, 3, 523–529, May 1952.

Problem treated is determination of two-dimensional strain components under finite homogeneous strain from measurements of distorted form of an initially square grid. Definitions of strain components are unconventional, but results are consistent with definitions. A numerical example is given. Applications to cable sheaths do not include sufficient data to render results generally useful. R. E. Newton, USA

3351. Blaise, H., Band spring—a new machine part. Calculation and application possibilities (in German), *ZVDI* **94**, 9, 253–258, Mar. 1952.

Author deals with analysis of the "band spring," also known in this country as a "neg'ator." Spring consists essentially of a

strip or band wound to a certain natural radius of curvature r_0 which may vary along length of the strip. Strip is usually wound on a roll having a radius of curvature greater than r_0; spring force is developed on unwinding strip from roll. By varying r_0 along strip length, various types of load-deflection characteristics may be obtained, i.e., positive slope (load increasing), constant load, or negative slope (load decreasing with deflection). The word "neg'ator" is based on this latter characteristic.

Methods of manufacture of spring to obtain these different characteristics are discussed. An expression is derived for load in terms of flexural rigidity EI, natural radius r_0, and expanded (or wound) radius r_w. Author does not take into account effect of transverse curvature of strip occuring during unwinding which will reduce load appreciably (see Votta, following review). Typical applications are also discussed, and comparison with other spring types is made. No data on fatigue life of springs are given. A. M. Wahl, USA

3352. Votta, F. A., Jr., The theory and design of long-deflection constant-force spring elements, *Trans. ASME* **74,** 4, 439–450, May 1952.

Author presents a thorough study of three basic types of the ingenious spring element known as a neg'ator.

In one form, the neg'ator consists of a flat strip wound into a very tight spiral and extended by a force applied to the external free end at right angles to the axis of the spring, the axis being free to rotate. Such a spring has a force which is substantially constant for any extension. This and other characteristics are compared with those of the conventional spiral spring.

The theory and design of the basic types are given, together with numerous applications. H. D. Conway, USA

3353. Coleman, W., Improved method for estimating fatigue life of bevel and hypoid gears, *SAE Quart. Trans.* **6,** 2, 314–331, Apr. 1952.

For computing the strength of tooth roots and tooth flanks, sufficiently reliable methods exist; but for lightweight constructions where it is necessary to know the fatigue life of the gears, an exact rating is still uncertain. Fatigue strength of the tooth roots for spiral, bevel, and hypoid gears is author's theme. The presented analysis contains many novel assumptions and empirical factors to account for the peculiarities of such gears. Load distribution, the most unfavorable position of load application, tooth and fillet form, finish, effective face width, material, size, mounting, dynamic load influence, and temperature are considered by calculating the tensile stress in the fillet. Application of the theory to test results gives a graph for estimating fatigue life of such gears. The paper will have considerable interest for experts.

Pavel Kohn, Czechoslovakia

3354. Girkmann, K., and Tungl, E., On the connection of angle bars (in German), *Öst. Ing.-Arch.* **6,** 3, 255–265, May 1952.

A theoretical determination is made of the elastic stress distribution in a structural angle transmitting a force along its length. The angle is assumed to be attached to a structure, say by spot welding, at a point on one leg of the angle; the other leg is free. The known stress distribution in the infinite plane loaded by a concentrated force in the plane is modified to satisfy the boundary conditions of the angle. An infinitely long angle is first assumed in the analysis, and Airy stress functions for each leg of the angle are obtained in terms of infinite integrals. The plane stresses are determined explicitly in the usual fashion by differentiating the stress functions. Then, by use of the principle of Saint Venant, the results are adapted for use with angles of finite length. Stress distributions are plotted for four different sections of an angle having legs of equal length.

W. H. Hoppmann, II, USA

3355. Parkes, E. W., The stress distribution near a loading point in a uniform flanged beam, *Phil. Trans. roy. Soc. Lond.* (*A*) **244,** 886, 417–467, Apr. 1952.

Elementary theory of bending leads to incompatibilities of displacement and stress distribution near sections at which load is applied; paper tries to remedy this. Author considers cases where beam is loaded through web and through flanges, and finds stress concentrations in outer fibers of flanges; maximum stress concentrations occur at loading section and can be expressed by simple formulas. For both cases, maximum concentration factors occur in short beams with large flanges and thin webs.

Theory agrees well with tests on mild steel beams. Analysis is compared with those of J. Taylor ["Stresses in built-up beams due to an abrupt change in shear stress at a loading section," *Roy. Aircr. Establ. Rep. Struct.* 48, 1949] and H. F. Winny [AMR **4,** Rev. 610].

From author's summary by H. D. Conway, USA

Plates, Disks, Shells, Membranes

(See also Revs. 3319, 3349, 3374)

3356. Horvay, G., Bending of honeycombs and of perforated plates, *J. Appl. Mech.* **19,** 1, 122–123, Mar. 1952.

Using the hexagonal grid analogy of I. Malkin [AMR **5,** Rev. 2319], author derives expressions for the effective elastic constants of an isotropic solid plate whose behavior will approximate that of the perforated plate. Dana Young, USA

3357. Reissner, E., Stress strain relations in the theory of thin elastic shells, *J. Math. Phys.* **31,** 2, 109–119, July 1952.

In general, exact analysis of the elastic deformations of thin shells is not possible and, indeed, cannot be expected; however, approximate analysis often suffices for technical applications, and there is a considerable literature on this aspect of the subject. Papers differ mainly in the methods used for the derivation of the fundamental equations and also through the retention or neglect of certain terms connected with the initial assumptions; these assumptions are difficult to justify and no satisfactory conclusion has yet been reached. Shell analysis in its simplest form usually involves the derivation, first, of consistent approximations (A) to the stress and displacement distributions in terms of the zero-th and first-order stress moments and of certain quantities, such as displacements and curvatures, defined in the middle surface, respectively; and, second, of (a) dynamical and (b) approximate stress-strain equations involving the quantities introduced in approximations (A). Approximations (A) are essentially finite power series in a variable, specifying distance from the middle surface and with coefficients that are dependent on variables specifying position in the middle surface. The remarks now apply mainly, but not exclusively, to linear problems of equilibrium with zero body force associated with shells of revolution and of homogeneous isotropic material. The determination of equations (a) is straightforward, but that of equations (b) is less straightforward and here much depends upon the assumptions made in establishing the approximations (A). Love, in preliminary analysis, made these assumptions: (1) The undeformed middle surface normals deform without change in length into the deformed middle surface normals, and

the stresses in the shell-thickness direction are small compared with other stresses; and (2) the shell-thickness minimum radius of curvature ratio is much smaller than unity. Subsequently, Love and, more recently, other writers, including Flügge, Reissner, Byrne, Green, and Zerna, have attempted to relax some of these assumptions, in particular (2), but Reissner has established that the analysis may not be self-consistent because errors involved in assumptions (1), (2) can be of same order of magnitude.

In the present paper, which contains a further study of the problem undertaken mainly to simplify previous work of Hildebrand, Reissner, and Thomas, a new variational principle due to Reissner is applied to derive simultaneously equations (a) and (b) appropriate to the axially symmetric deformations (which restriction is easily removed) of shells of revolution in equilibrium under zero body force and with elastically preferred directions along the middle surface normals, sandwich as well as isotropic shells thus being included. The correction terms to Love's preliminary analysis thus obtained are compared with those obtained by Love and others. It is not concluded that all second-order terms are obtained, because the analysis does involve the approximations (A); however, the author avers that all significant correction terms have been obtained. The use of more general assumptions necessarily incorporates into the analysis second- and higher-order stress moments together with derivatives of the zero-th and first-order stress moments; such quantities are not normally considered to be within the framework of shell theory, and then an analysis similar to that initiated by Chien may be preferable. H. G. Hopkins, USA

3358. Berio, A., Application of the theorem of least work to the study of statically indeterminate vault membranes (in Italian), *Ist. Lombardo Sci. Lett. R. C. Sci. Mat. Nat.* (3) **14** (83), 297–310, 1950.

For the extensional or "membrane" theory of thin shells, the author calculates the strain energy in general and then shows by examples how the theorem of least work can yield quick solutions to statically indeterminate problems. The two examples concern a vault of circular cylindrical section. C. Truesdell, USA

3359. Das Gupta, S. C., Some simple problems of thick conical shells, *Bull. Calcutta math. Soc.* **43,** 3, 119–122, Sept. 1951.

Stresses and deflections are calculated in a thick shell bounded by coaxial conical surfaces due to an axial force and a couple about the axis applied at the common vertex. The semi-inverse method of solution is used in both problems.

For the axial force problem, it is assumed that the component of displacement u_ϕ in spherical coordinates (r,θ,ϕ) vanishes, while the other two are given by: $u_r = f_1(\theta)/r$ and $u_\theta = f_2(\theta)/r$. The differential equations of equilibrium in terms of displacements are used to determine $f_1(\theta)$ and $f_2(\theta)$ in terms of three arbitrary constants. By means of the boundary conditions, two of the constants are expressed in terms of the third which will be obtained when the magnitude of the applied force is given. An expression for the applied force in terms of the undetermined constant is obtained by integrating the stresses over the surface of a small sphere bounded by the cone, the center of the sphere being at the vertex of the conical shell.

For the case of the axial couple, it is assumed that u_r and u_θ vanish, while u_ϕ is given by $f(\theta)/r$. By means of the equation of equilibrium, $f(\theta)$ is obtained in terms of a single arbitrary constant. The constant is determined when the magnitude of the applied couple is given. The applied couple is expressed in terms of the constant by same method used to find the applied force.

In both problems, the stresses are derived from the displacements by means of the stress-strain relations. The method is both simple and direct. Reviewer believes the results to be new. J. H. Baltrukonis, USA

3360. Szabó, I., Thick circular plate on elastic and rigid foundation loaded rotationally symmetrically in the axial direction (in German), *ZAMM* **32,** 4/5, 145–153, Apr./May 1952.

This is a third publication by the author on thick circular plates. For the first, see AMR **5,** Rev. 1033. In the earlier publications, the solution is described for the loaded circular plate on elastic foundation with and without friction between plate and foundation.

This article describes a solution for the plate on a rough foundation, assuming that (1) the normal stress of a point in the contact plane of plate and foundation is proportional to the displacement of this point, and (2) the shear stress in this point is proportional to the normal stress. Solutions are given for plates which are clamped and free, respectively, on the circular boundary; moreover, the influence of their own weight can be taken into account. J. W. Cohen, Holland

3361. Wuest, W., Effect of bending in thick-wall, high-pressure pipes of arbitrary asymmetrical cross section (in German), *ZAMM* **32,** 2/3, 90–92, Feb./Mar. 1952.

Author considers a long straight tube of arbitrary cross section, closed at the ends and subject to a uniform normal internal pressure. Pressure on the ends of the tube causes an elongation which is modified by the transverse expansion due to pressure on the walls. Due to asymmetry, the resultant of pressure on the ends may act at a point which differs from the centroid of the cross-sectional area of the tube material, introducing a couple which causes the tube to bend. Assuming that sections of the tube remain plane during deformation, author explicitly determines the longitudinal strain for all points of the cross section. The method of solution uses Airy's stress function but does not require explicit knowledge of the stress distribution, which is not determined. Author points out that the effect of pressure on the walls of the tube simply modifies the elementary solution for end forces alone by the factor $1 - 2\nu$, where ν is Poisson's ratio. R. A. Clark, USA

3362. Carlier, H., Contribution to the study of pipes subjected to high temperature (in French), *Chaleur Industrie* **33,** 139–150, May 1952.

Author refers to privately published method [Carlier, H., "La tuyauterie de vapeur. Son aptitude a absorber les effets de la dilatation," Waudrez-lez-Binche, Belgium, 1935] of elastic center type of stress analysis of plane and space piping systems under thermal expansion, paralleling Spielvogel's method [Spielvogel, S. W., "Piping stress calculations simplified," McGraw-Hill Book Co., New York, 1943], and supplements this by notes on simple determination of distorted shape. Paper is a worth-while contribution to literature on piping flexibility. A. R. C. Markl, USA

3363. Jung, H., Contribution to statics of circular plates (in German), *ZAMM* **32,** 2/3, 46–61, Feb./Mar. 1952.

Using the Hankel transformation, author solves differential equation for bending of circular thin plates. The deflection in rotationally symmetric pattern is found. Typical examples are worked out as sample problems. This method is also applied to elastically supported plates. The case of the thick circular plate is also discussed. H. H. Hilton, USA

3364. Berio, A., On the equilibrium equations and the congruence of plates (in Italian), *Ist. Lombardo Sci. Lett. R. C. Sci. Mat. Nat.* (3) **14** (**83**), 329–370, 1950.

By truncating general series developments in powers of the ratio (thickness/least linear dimension), W. Z. Chien [*Quart. appl. Math.* **1**, 297–327, 1944; **2**, 43–59, 1944] has classified the equations governing the deformation of plates into twelve types. The author objects to the arbitrariness of this formal procedure. He prefers to consider the phenomena directly and to give some mechanical or geometrical reason for the neglect or retention of each term. If, in the equilibrium equations, the second fundamental tensor of the bent plate may be neglected, he calls the deflection "infinitesimal"; if not, but if squares of the displacement gradients are negligible, he calls the deflection "small"; in all remaining cases the deflection is "finite." In the author's approach, as in any other, the difficulty lies not in the equilibrium equations but in the appropriate simplification of the relations between force quantities and displacements. Here, as is customary, the author uses series developments. He concludes that there are in all seven types of plate problems, the equations for five of which he works out. Unfortunately, he does not indicate the differences and similarities between his results and those of Chien and others.

C. Truesdell, USA

3365. Grigolyuk, E. I., Some problems of stability of circular plates with nonuniform heating (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **6**, 73–84, 1950.

A thin annular disk of constant thickness, its center coinciding with the pole of the coordinate system, is heated in such a way that the temperature is a function of the radial distance r only. Under this condition we have a two-dimensional problem with the stress distribution symmetrical with respect to the center of the disk. The following cases are considered: (1) The outer edge freely supported; (2) the outer edge fixed, but able to expand; (3) the outer edge rigidly fixed; (4) the outer edge hinged. In all cases the temperature is given by the formula, $t = t_0 + t_1(1 - \rho)^n$, where $\rho = r/b$, and b is the outer radius of the disk. For all cases, the critical temperature at the inner edge and the critical stresses are found. Solving the differential equations with given boundary conditions, the author uses a method which he calls the method of Galerkin, but gives no reference. The author also gives tables and graphs for the stresses (in dimensionless form), and the coefficients in the formula for the critical temperature, depending on different values of n and $\alpha = a/b$, where a is the inner radius, b is the outer radius of the disk. All the tables and graphs were calculated assuming that the Poisson ratio equals 1/3. A numerical example for $n = 4$ is appended at the end.

Courtesy of Mathematical Reviews T. Leser, USA

Buckling Problems

(See also Revs. 3291, 3295, 3313, 3385, 3386, 3415)

3366. Ziegler, H., Buckling of straight rods subjected to torsion (in German), *ZAMP* **3**, 2, 96–119, Mar. 1952.

Stability problems concerning thin rods and shafts subjected to torsion and thrust are usually treated under the assumption that, during deflection, the moment vectors of the external couples remain parallel to the axis. In consequence of this rather questionable assumption, these problems are nonconservative; in some very simple buckling cases, the critical load is found to be zero.

It seems more appropriate to assume that the vectors of the forces contributing to the external moments retain their directions. Then, as a rule, the moment vectors are inclined; their slope, however, differs from that of the deflection curve and depends on the manner in which the forces are applied. Under this assumption, the problem is conservative and yields new values for the critical load. As a first application, author recalculates buckling moments for prismatic rods with two equal flexural rigidities, subjected to torsion under various end conditions.

From author's summary by Sverre E. Kindem, Norway

3367. Bijlaard, P. P., and Fisher, G. P., Interaction of column and local buckling in compression members, *NACA TN* 2640, 110 pp., Mar. 1952.

The theoretical and experimental investigations are given of interaction between column and local buckling in compression members. Test results showed no noticeable interaction effect for square tubes tested. Theory indicates negligible interaction for common sizes of box, I-, H-, and channel sections, and for those T- and L-sections for which one leg is not significantly more stable than another. An ingenious application of the solid-guide method is used to prevent local buckling in measuring stress-strain curves for the square-tube material.

Carboloy knife edges were used to obtain the best possible simple-support end conditions. Paper shims, 0.0015 in. thick, were inserted between upper machine head and a hardened-steel bearing block until the high-to-low deviation of strain on eight gage lines was less than 3% at about two thirds of predicted critical load. Excellent agreement was obtained between theoretical and experimental buckling loads. Samuel Levy, USA

3368. Karpinski, J., New method of increasing the carrying capacity of a strut axially loaded at the ends (in French), *Publ. int. Assn. Bridge struct. Engng.* **11**, 291–302, 1951.

Author considers the lateral buckling of compressed struts supported laterally by crossbars introduced between the strut and prestressed wires fixed to the ends of the strut. He considers three cases. In the first, there are two crossbars between the middle point of the strut and the wires; in the second, there are several pairs of crossbars at intermediate points of the strut. In both these cases, the lower end of the strut is fixed and the upper end is loaded and is prevented from moving laterally. In the third case, there are several crossbars at intermediate points, the lower end of the strut is clamped while its upper end is loaded but free to move otherwise. By assuming the equation of the central line of the strut after buckling in the forms (1) $y = a \sin \pi x/L$, (2) $y = 4f^2x(L - x)/L^2$, (3) $y = a \cos (1 - \pi x/2L)$ in the three cases and applying Timoshenko's energy method, author shows that the critical load in each case is about three times Euler's load. The experimental results of tests on wooden models, steel specimens, and on rolled beams are presented to show a good agreement with theoretical forecasts.

D. N. Mitra, India

3369. Weiskopf, W. H., Behavior of an idealized steel H-column above the elastic range, *Welding J.* **31**, 7, 353s–360s, July 1952.

Paper analyzes idealized H-section columns of mild steel subject to various boundary conditions. The stress-strain curve is idealized as three straight lines representing the elastic, yield, and strain-hardening regions. It appears that proper consideration of the yield region has been neglected in the analysis, possibly invalidating the results obtained. George Gerard, USA

3370. Seide, P., and Barrett, P. F., The stability of the compression cover of box beams stiffened by posts, *NACA Rep.* 1047, 16 pp., 1951.

Supersedes paper reviewed in AMR **4**, Rev. 1144.

3371. Ziegler, H., Stability criteria in elastomechanics (in German), *Ing.-Arch.* **20,** 1, 49–56, 1952.

In connection with the stability of nonconservative systems, author questions the validity of stability criteria which he states as (1) static criterion, for which critical load is the least load under which a nontrivial equilibrium position, in addition to the original one, exists; (2) energy criterion, for which critical load is the least load under which the total potential energy of the system is no longer a positive definite.

Instead, author proposes what he terms kinetic criterion, for which critical load is the least load under which an approximate disturbance does not lead to a dynamical displacement (motion) within the immediate neighborhood of the equilibrium position. As a means of "proof," the nonconservative example of a fixed-ended column with a tangential force (along the center line) at the free end is considered. By means of a simple model for this column, in the form of two rigid bars hinged at the middle and at wall (essentially a double pendulum), theorems for this case are established, and, by application of kinetic criterion, the buckling load is determined. In the course of discussion, the importance of internal damping in the system as it affects the buckling load is brought out. Paul M. Naghdi, USA

3372. Raher, W., General stability condition for curved beams, *Öst. Ing.-Arch.* **6,** 3, 236–246, May 1952.

P. Funk has given the stability theory of straight beams. Author extends this theory to originally curved beams. For this purpose, the second variation of the deformation energy of curved beams is necessary. A general formula is given. This problem is similar to the solving of gyroscope motion by Lagrange. As an example, the problem dealing with the eight formed by a closed circular ring is treated. L. Föppl, Germany

3373. Grigolyuk, È. I., The stability of circular annular plates (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **5,** 2, 83–95, 1949.

The stability of a thin circular annular plate, compressed by constant distributed loads in the plane of the plate and normal to the edges, was investigated by G. H. Bryan [*Proc. Lond. math. Soc.* **22,** 54–67, 1891], A. Dannik, A. Nádai [*ZVDI* **59,** 169–174, 1915], A. Lokchine [*C. R. Acad. Sci. Paris* **189,** 316–317, 1929], and E. Meissner [*Schweiz. Bauztg.* **101,** 87–89, 1933]. The values of critical loads are found, among others, from the differential equation of equilibrium, which in turn has to be solved in terms of Bessel functions. All the above investigators obtained the exact solutions by using Bessel functions. The author of this paper uses an approximate method, which he calls the method of Galerkin, and solves the problem for several different kinds of supports at the outer and inner edges. He compared his results with the exact solutions of the previous investigators, and they differed by 2% to 4% at the most. Author claims that the Galerkin method saves a great amount of computational work connected with the evaluation of the Bessel functions.

Courtesy of Mathematical Reviews T. Leser, USA

3374. Seide, P., The stability under longitudinal compression of flat symmetric corrugated-core sandwich plates with simply supported loaded edges and simply supported or clamped unloaded edges, *NACA TN* 2679, 27 pp., Apr. 1952.

Paper uses the orthotropic plate theory of Libove and Batdorf [AMR **1,** Rev. 799] and the expressions for the various stiffnesses of corrugated-core sandwich plates obtained by Libove and Hubka [*NACA TN* 2289] to find expressions for the buckling loads of the panels described in the title. Charts are presented showing the variation of buckling load with differing stiffness parameters. K. H. Griffin, England

3375. Bijlaard, P. P., Analysis of the elastic and plastic stability of sandwich plates by the method of split rigidities. III, *J. aero. Sci.* **19,** 7, 502–503, July 1952.

In part I of his paper [AMR **4,** Rev. 3518], author derived a simple formula which gives the buckling load as a function of the special buckling loads of the two extreme cases of deformation (only bending without shear and shear alone). In the present paper, this formula is derived energetically by formulating the work done by the restraining forces and that done by the deflecting forces. Author discusses his results in comparison with those of Seide [AMR **5,** Rev. 1991] for sandwich plates with simply supported loaded edges and clamped unloaded edges.

H. Neuber, Germany

3376. Bijlaard, P. P., Taking account of the compressibility of the material in the plastic buckling of plates, *J. aero. Sci.* **19,** 7, 493–494, July 1952.

Stowell derived a theory of plastic buckling of column plates, based on deformation theory and with the assumption that the column and plates in plastic buckling remain in purely plastic state in the early stage of buckling. The ratio of critical stress of plastic case to that for the elastic case was obtained by assuming Poisson's ratio in both cases to be 1/2. The amount of error introduced by this assumption was shown by Stowell and Pride to be negligible (about 1%) for both the simply supported flange and simply supported plate. Bijlaard points out that the sign of correction for simply supported flange cases should be reversed.

T. H. Lin, USA

Joints and Joining Methods

(See also Revs. 3428, 3441)

3377. DeGarmo, E. P., Preheat vs. low- and high-temperature stress-relief treatments, *Welding J.* **31,** 5, 233s–237s, May 1952.

From test results on large specimens, the following conclusions appear to be justified: (1) The use of preheating at 400 F, postwelding heat treatment at 1200 F, or controlled low-temperature stress relief produces marked improvement in the performance of weldments under static load conditions. (2) The results obtained by 400 F preheat are as good as those obtained by 1200 F postwelding heat treatment. (3) Controlled low-temperature stress-relieving does not improve weldment performance as much as either 400 F preheating or 1200 F postwelding heat treatment. (4) The microstructure obtained by the use of 400 F preheat is very nearly the same as that resulting from 1200 F postwelding heat treatment, but the heat-affected zone is wider. (5) The sharpness of the transition between the parent metal and the heat-affected zone and between the heat-affected zone and the weld metal is less in weldments which have 400 F preheat or 1200 F postwelding heat treatment than in as-welded weldments or those treated by the controlled low-temperature stress-relieving process. From author's summary

3378. Smith, C. O., Funk, E. R., and Udin, H., An analytical study of aluminum welding, *Weld. Res. Counc. Bull. Series* no. 12, 8 pp., June 1952.

Calculations are presented for the temperature history of points in a 61S-T6 aluminum plate under varying conditions of source velocity and heat input. These conditions were subsequently duplicated by experiments in which a tungsten or a consumable electrode arc became the hypothetical point source of heat. The decrease in hardness at any point in the plate is predicted from a temperature-modified time vs. transformation curve, developed

from isothermal reaction rates. The predicted hardness values are compared with the measured hardness values as a check on the applicability of the analytical method.

From authors' summary by E. Siebel, Germany

3379. Stern, E. G., Immediate vs. delayed holding power of nails, *Virginia Poly. Inst. Wood Research Lab. Bull.* no. 8, 12 pp., Apr. 1952.

The withdrawal resistance of plain-shank nails significantly decreases as a result of wood deterioration along the nail shank in the presence of given amounts of moisture in the wood, while the initially even greater withdrawal resistance of properly threaded nails may decrease little or even increase under identical conditions.

Because of this decrease in the efficiency of plain-shank nails, the significance of their immediate withdrawal resistance is limited under given conditions. Thus, the design of joints assembled with plain-shank nails may have to be based on their delayed withdrawal resistance.

Results of recently performed tests on the holding powers of various nails and wood assemblies are presented to form a basis for such conversion from immediate to delayed withdrawal resistance and strength. From author's summary

3380. Murphy, G., Analysis of stresses and displacements in heat-exchanger expansion joints, *Trans. ASME* **74,** 3, 397–402, Apr. 1952.

A procedure is developed for the analysis of stresses and displacements in an expansion joint which can be considered a surface of revolution. The conjugate frame analysis leads to a method of successive approximations, but author states the solution will be rapidly convergent. He believes thermal gradients can be introduced. An example is presented.

Marshall Holt, USA

Structures

(See also Revs. 3331, 3354, 3370, 3416, 3439, 3440, 3583, 3588)

3381. Homberg, H., Bridge with elastic member between the principal steel girder and the roadway platform (in German), *Bauingenieur* **27,** 6, 213–216, June 1952.

In a bridge with a common action of steel girders and reinforced-concrete platform, the stresses of the latter increase when its depth is kept constant and the span of the bridge becomes larger. In order to relieve it from part of the stresses due to interaction, author proposes to connect the girder with the slab by an elastic member, e.g., a horizontal truss. In particular, stress concentrations due to single loads and at the supports of continuous beams are smoothed out by this device. Effect depends on deformability of connecting member. Solutions for main cases of a single-span beam are stated; no proof is given. Evaluation needs from 10 to 40 terms of a Fourier series; nevertheless, convergence is claimed to be satisfactory. Results of several examples are discussed. H. Craemer, Germany-Egypt

3382. Farquharson, F. B., von Kármán, T., and Dunn, L. G., Aerodynamic stability of suspension bridges. Part III. The investigation of models of the original Tacoma Narrows bridge under the action of wind, *Univ. Wash. Engng. Exp. Sta. Bull.* 116, part III, 126 pp., June 1952.

Description is given of construction of an unorthodox-type wind tunnel with air flow delivered at right angles to longitudinal axis. Wind tunnel as constructed was over 100 ft long and 38 ft wide. Controls for tunnel and model are adequately described.

Detailed information is given on design and construction of a full aerodynamic model of the original Tacoma Narrows bridge to a linear scale factor of 50. Erection of model is described, illustrating how it was finally positioned by the use of hydraulic jacks.

Behavior of above model in wind tunnel is considered under varying wind velocities and construction modifications, such as addition of circular fairing and closed and open decks. Symmetric and asymmetric modes are plotted for various conditions as well as other pertinent data. Side-span modifications are described utilizing unloaded backstay condition as well as side spans replaced by springs. Effectiveness of diagonal tower stays is investigated as well as effect of altering torsional stiffness of model towers.

In addition to tests on above model, tests are described on "section" dynamic models under three different mounting conditions. It is shown that a dynamic section model represents a short section of suspended structure, and it should be built to scale with respect to weight and shape if it is to represent the characteristics of the section. Numerous double amplitude "plots" are given for varying conditions.

All of preceding is summarized well in separate chapter which also includes comparison with tests made at the California Institute of Technology by von Kármán and Dunn. Complete tabulation of $(V/Nb)_C$ for all configurations and models for vertical and torsional oscillations are given.

Reviewer believes the principal contribution of this work is as follows: Part III will serve as classic in wind-tunnel and model construction, instrumentation, and operation for those who, in the future, will be interested and concerned with the effect of aerodynamic forces on suspension bridges. It also demonstrates that careful experimentation with scale models can predict with reasonable accuracy the performance of the prototype under action of a perfect wind. However, as the authors state, the impact of a natural wind on a given bridge (or proposed one) is still beyond definite prediction, and, for this reason, critical judgment should be exercised in interpreting model tests.

F. L. Castleman, Jr., USA

3383. Cicala, P., Optimum distribution of wing skin thickness (in Italian), *Monogr. Lab. Aero. Polit. Torino,* 16 pp. = *Atti Accad. Sci. Torino* **85,** 1950–1951.

Statically, the skin of a wing produces torsional stiffness. Since the chord length l of the cross section varies with y, the thickness s of the skin must also vary with y to obtain a minimum weight wing. It is known that for a constant ratio of applied moment to twist, s should vary as $1/l^2$. But other curves $s(y)$ are obtained if the maximum angle for several kinds of distorting moments is fixed; a final variation is to admit apertures ($s = 0$) near the fuselage; the wing there will support torsional moments owing to the bending stiffness of the longerons. In this way author obtains 5 functions $s(y)$ which he discusses in detail, and which he graphically represents for a trapezoidal wing of taper ratio 1/2.

K. Marguerre, Germany

3384. Sattler, K., Composite truss with a reinforced-concrete chord (in German), *Bautechnik* **29,** 5, 118–124, May 1952.

Paper analyzes theoretically a new kind of bridge truss invented by the author, in which one chord and the filling members are steel bars, whereas the other chord is made of reinforced or prestressed concrete.

Owing to the creep and shrinkage of the concrete, the forces in the bars vary with time under constant load. Paper is based on Dischinger's fundamental results [*Bauingenieur* **20,** p. 54, 1939] and establishes the formulas giving this time variation. Statically

determinate systems are treated first, then statically indeterminate ones.

Paper closes with a short account of the application of this theory to a continuous bridge on four supports (spans: 100, 200, and 100 m). Ch. Massonnet, Belgium

3385. Cowan, H. J., Design of eccentrically loaded reinforced concrete columns, *Civ. Engng., Lond.* **47,** 550, 551, 552; 296–298, 400–403, 486–487; Apr., May, June 1952.

Paper presents a new method for design of eccentrically loaded columns based on principle of superposition. Section is designed to resist bending moment due to eccentricity of column load, using well-known equations for rectangular reinforced-concrete beams; area of reinforcement is then reduced for direct compression due to column load. In the standard method, dimensions of section are assumed, and neutral axis and maximum stresses in steel and concrete are then calculated. In the present method, neutral axis ratio is assumed, and dimensions of section are calculated from maximum permissible stresses of materials.

From author's summary by R. B. McCalley, Jr., USA

3386. Hognestad, E., A study of combined bending and axial load in reinforced concrete members, *Univ. Ill. Engng. Exp. Sta. Bull. Ser.* no. 399, 128 pp., Nov. 1951.

Paper presents test data on the behavior of eccentrically loaded reinforced-concrete columns. 120 specimens (90 square tie and 30 cylindrical spiral) were tested to destruction; variables were eccentricity, percentage of reinforcement, and concrete strength. Concrete and steel strains were measured to failure by SR-4 gages.

A review of the literature on ultimate failure theories of reinforced concrete is presented with discussion of the assumptions of the various theories. Author presents mathematical expressions for predicting behavior of eccentric columns up to and at failure. Constants for the expressions are adjusted to fit experimental data, giving excellent agreement between predicted and actual column behavior. Values agree with Whitney's simpler expressions, which give behavior only at failure.

I. A. Benjamin, USA

3387. Pickett, G., and Ray, G. K., Influence charts for concrete pavements, *Trans. Amer. Soc. civ. Engrs.* **116,** 49–73, 1951.

Paper gives influence charts for determination of deflections and moments in pavement slabs on subgrades which may be either deep elastic solids or a heavy liquid characterized by a subgrade reaction proportional to deflection. Charts are used by counting squares and multiplying by a numerical factor indicated. Loads are considered near an edge, at an edge, or in the interior. Load may be distributed (uniformly) over any shape of area. Paper describes methods for computing the charts and illustrates their use. N. M. Newmark, USA

3388. Langefors, B., Analysis of elastic structures by matrix transformation with special regard to semimonocoque structures, *J. aero. Sci.* **19,** 7, 451–458, July 1952.

Complex elastic structures, such as airplane wings, are analyzed by a tensorial approach that is equally applicable to other intricate engineering structures that may include mechanical, electrical, and other forces besides elastic ones. The structure under investigation is subdivided into several components, and the equations of each component are established independently of the presence of the others. The equations of all components are afterward combined into those of the resultant structure in an automatic manner by a matrix of transformation C, the so-called "connection tensor" representing the topographic interrelations of the components. The method allows the reduction of the large number of unknowns by various approximations, such as assuming each component as a "stiff" system. These approximate assumptions also are handled quite automatically by means of matrixes of transformation C. The procedure is illustrated by a study of sweptback wings with different angles of sweepback.

Gabriel Kron, USA

3389. Henson, G., Stress distribution near a rectangular cut-out in a reinforced circular cylinder due to direct shear loading and torque. Part I—Test results, *Coll. Aero. Cranfield Rep.* 51, 7 pp., 16 figs., Jan. 1952.

Effect of rectangular cutouts in an airplane fuselage was investigated by testing, under direct shear and torsion, a reinforced cylinder having two horizontally opposite cutouts. Tensile and shear strains in the skin and reinforcing members were measured with resistance gages. The presence of the cutouts increased maximum stresses due to direct shear 160%, and stresses due to torsion 240%. Comparison with an earlier test on the same specimen when provided with transverse floor beams shows effect of latter. Experimental results are stated to be in fair agreement with theoretically predicted stresses given in a separate and as yet unpublished part of the report.

R. J. Roark, USA

3390. Wilkins, R. J., Analysis of groups of piles. A semigraphical method based upon displacements, *Concr. Constr. Engng.* **47,** 7, 209–211, July 1952.

Well-known methods of analysis are used for the solution of groups of piles. Solutions of two inclined piles joined at the apex are given. Pin and fix-ended joints are considered.

Elio D'Appolonia, USA

3391. Koreleski, J., Application of the iteration method (Cross) to frames with angle braces (in Polish), *Inżyn. Budown.* 9, 1, 20–23, Jan. 1952.

Well-known Cross iteration method, so powerful in engineering applications, is applied by author to solution of two examples: One-span frame with angle braces uniformly loaded, and four-span continuous beam uniformly loaded along one span. Since the procedure is widely used, it will not be outlined here.

M. Z. Krzywoblocki, USA

3392. Raithby, K. D., Fatigue tests on typical two spar light alloy structures (Meteor 4 tailplanes) under reversed loading, *Aero. Res. Counc. Lond. curr. Pap.* no. 88, 13 pp., 12 figs., 1952.

Results are given for fatigue tests on six Meteor 4 tailplanes, vibrated in flexure under simple reversed loading, ranging from $\pm 10\%$ to $\pm 30\%$ of the static failing load. Corresponding endurances varied from about 5×10^6 to 0.06×10^6 cycles for complete failure of a spar boom. Skin-cracking and rivet failures occurred at an appreciably lower number of cycles. In each test the alternating load was kept constant, although progressive skin cracking caused a considerable change in alternating stress at the section where eventual failure occurred. The test results are discussed and the endurance curves obtained are compared with data from reversed-axial-load fatigue tests of 14S-T.

R. R. Heldenfels, USA

3393. Bennett, E. W., The design of simple and composite prestressed concrete beams, *Concr. Constr. Engng.* **47,** 5, 141–147, May 1952.

Paper introduces method of designing prestressed-concrete I-beams and beams made of precast and "cast-in-situ" parts. Charts are provided for simple beams and relatively simple

formulas are derived for composite beams. Numerical examples are worked out in detail. Ai-ting Yu, USA

3394. Walley, F., Composite construction design problems in prestressed concrete, *Civ. Engng., Lond.* **47,** 551, 380–382, May 1952.

Author applies Moersch's design suggestions to T-beams comprising prestressed web and nonprestressed slab, investigating four cases. Either web is propped or not, when wet slab concrete is added, and in each case either uniformity is assumed or the E-ratio of slab and web is taken as 0.8 and differential shrinkage is considered. These influences result in increased tensile stresses at bottom of web with reduced carrying capacity. Also without propping, carrying capacity is greatly reduced, as shown by author who states: "It should be realised that the conditions laid down in these calculations are arbitrary and should be related to the actual job and the erection programme." Results of arbitrary calculation are not compared with test results. Cases with and without propping must be compared separately. Constructions of first type cracked at approximate loading calculated for uniformity, although different E-values and differential shrinkage were applied. Actual E-values ought to be considered in relation to actual stresses. E-values will vary little for high stresses in high-strength web and low stresses in low-strength slab; thus uniformity can be assumed. With propping where stresses in adjoining fibers of web and slab are similar, difference in E may be greater than 20%. Reviewer believes that tests are necessary for second type to obtain data before arbitrary calculation can be used. P. W. Abeles, England

3395. Rapp, G. M., Lightweight prestressed wood arches as a new type of roof construction, *For. Prod. Res. Soc.* Prepr. 218, 8 pp., June 1952.

Relatively thin lumber and plywood sprung and held in a flat arch by horizontal tie members and, thus, prestressed in bending are shown to possess adequate strength and stiffness to serve as roof supports for small buildings. The efficient use of lumber of small cross section which almost always can be made available in at least air-seasoned or even kiln-dried form, the easy handling and installation of these light-weight flat members which are transported in bulk and, thus, shipped with a minimum effort and space requirement, and the strength and stiffness they provide if installed in arched shape make this arch-roof support attractive for spanning such buildings as garages and other small-span structures. Tests are reported on full-size arches of 8-, 20-, and 24-ft spans. E. George Stern, USA

3396. Howe, J. W., Wind pressure on elementary building forms evaluated by model tests, *Civ. Engng., N.Y.* **22,** 5, 42–46, May 1952.

Low-velocity wind-tunnel tests have been performed on 124 model buildings and 21 model walls for the determination of wind pressures. Results are presented in terms of pressures, lift and drag coefficients, centers of pressures, pressure distribution, and the effect of many variables, such as relative building dimensions, roof slopes, and building shapes. Results of this nature should be of considerable interest to the structural engineering profession, as extreme differences from present design procedures are indicated by the model tests. [See also AMR **5,** Rev. 2609.] Robert J. Hansen, USA

3397. Homberg, H., On the load distribution through shearing forces, theory of plate grid structures (in German), *Stahlbau* **21,** 3, 4, 5; 42–43, 64–67, 77–79; Mar., Apr., May 1952.

If spacing of main and transverse girders of a plate grid structure is narrower than the effective width of plate, horizontal shear forces may be transmitted through the plate between adjacent girders. This results in partial relief of the heavily loaded members at the expense of members with less load.

Author establishes a general theory of plate grid structures, taking the effect of plate shear stiffness into consideration, in addition to the bending and torsional stiffness of the main and transverse girders. The difficulty arising from huge number of redundant forces and members is reduced by forming groups of unknowns, which are given the form of sin and cos series, so that the matrix of equations of elasticity separates into independent groups.

The method appears to represent an appreciable refinement of available theories. Application to practical problems involves extensive numerical work.

Paper is based on and supplements author's book reviewed in AMR **5,** Rev. 1380. Karl Arnstein, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 3333, 3335, 3346, 3411, 3412, 3418, 3419, 3431)

3398. Neményi, P. F., and Van Tuyl, A., Two-dimensional plastic stress systems with isometric principal stress trajectories, *Quart. J. Mech. appl. Math.* **5,** part 1, 1–11, Mar. 1952.

Carathéodory and Schmidt, in their paper on the maximum shear trajectories in plane plastic stress with the yield condition $\tau = (\sigma_1 - \sigma_2)/2 = \text{constant}$, discussed the possibility of these trajectories forming an isometric net. The authors generalize that study to an arbitrary yield condition $f(\sigma_1, \sigma_2) = 0$. A complete discussion shows that only for three distinct families of yield conditions, depending on from two to four parameters, do there exist isometric nets satisfying the conditions of the problem beyond the trivial nets consisting of concentric circles and concurrent straight lines. Among these yield conditions, the von Mises parabolic yield condition is found to be included. The linear yield condition is discussed in detail; it is shown that $\tau = \pm\sigma + \text{const}$ and $\sigma = \text{const}$ are degenerate cases, the latter falling under electrostatics. The complex functions $Z(z)$ characterizing the possible isometric trajectory patterns are given either explicitly or by equations involving quadratures. It is shown that among the isometric nets which are possible for certain yield conditions are all those which go into themselves either under a rotation or under a translation.

From authors' summary by W. M. Shepherd, England

3399. de Jong, J. J., Factors bearing on the creep of metals and alloys (in Dutch), *Ingenieur* **64,** 28, 0.92–0.101, July 1952.

A critical review is given of the effect of internal and external structural factors on the creep of metals. Some points, like effect of grain boundaries and grain-boundary segregation, structural changes of phases (the similar effect of carbide transformations on creep and temper brittleness is especially put forward), formation of phases from supersaturated solutions, superficial and internal oxidation and diffusion of other gases are dealt with in more detail. The importance of lattice deformations of high stability as arising from age-hardening, internal oxidation, and mechanical deformation for high creep resistance is particularly emphasized. J. H. Palm, Holland

3400. Thorne, C. J., Mathematical analysis of the four element linear molecular model, *Univ. Utah, Studies appl. Math.* no. 1, 8 pp., Oct. 1951.

Author presents mathematical solution in rather complicated form for four-element linear model consisting of two spring-dash-

pot systems in parallel. Method used is similar to author's previous analysis of three-element model [AMR **4**, Rev. 1149]. Object is to include effects of secondary creep not taken into account in previous analysis. A. M. Wahl, USA

3401. Herring, C., and Galt, J. K., Elastic and plastic properties of very small metal specimens, *Phys. Rev.* (2) **85,** 6, 1060–1061, Mar. 1952.

The discrepancies between the observed values of the yield stress and the creep rate of bulk metal and the values calculated for an ideal crystal are usually attributed to the motion of imperfections, particularly dislocations, in specimens of the bulk metal. If this is true, there is a strong presumption that the values of the properties of the physically small specimens should be much closer to those of the ideal crystal than those which have been observed with ordinary-sized specimens. This letter describes a series of very pretty experiments with microspecimens of tin, approximately cylindrical in cross section, diameter $1.8 \times 1.8 \times 10^{-4}$ cm, and a few mm long. Simple experiments on the bending of the specimens and on their creep rate showed that, compared with macrospecimens, they were able to sustain much larger stresses and strains without appreciable creep; e.g., in one experiment, a specimen sustained a strain of 10^{-2}, whereas the macro yield strain of tin is only about 10^{-4}.

R. M. Davies, Wales

3402. Kennedy, A. J., The creep of metals under interrupted stressing, *Proc. roy. Soc. Lond.* (*A*) **213,** 1115, 492–506, July 1952.

Constant-stress experiments show that the creep rate in polycrystalline lead, following reapplication of stress after a no-stress rest period, is greater than it would have been without the rest. A one-parameter equation is proposed for describing the creep curve after a rest period. The equation is shown to be satisfactory for rest periods of arbitrary duration following periods of creep also of arbitrary duration. Pulsed-stress tests were made and were compared with the calculated curves. All tests were made at room temperature. J. C. Fisher, USA

3403. Davis, E. A., Relaxation of stress in a heat-exchanger tube of ideal material, *Trans. ASME* **74,** 3, 381–385, Apr. 1952.

The relaxation of the radial and tangential stresses in an elastico-viscous thick-walled tube rolled into a rigid tube sheet is calculated for both plane stress and for axial stress equal to the average of the other two stresses. The results show that relaxation is a little slower for either case than for uniaxial tension. Experiments on an aluminum alloy show that the relaxation behavior is disturbed slightly by reloading because of strain-hardening and creep-recovery phenomena. J. D. Lubahn, USA

3404. Gibbons, D. F., Effect of strain ageing upon the distribution of glide bands in cadmium crystals, *Proc. phys. Soc. Lond.* (*B*) **65,** part 3, 387B, 193–195, Mar. 1952.

Results of observations of slip in cadmium single crystals are presented and correlated with stress-strain behavior.

Clustering of slip into macroscopic regions was observed only for the cadmium-nitrogen-alloy crystals and only coincident with a drop in load in a tensile test. Pure cadmium deformed without drop in load and with homogeneous distribution of slip. Clear differentiation of the drop-in-load effect due to solute atoms from that previously reported due to crystal orientation was obtained.

Formation of Lüders' bands in polycrystalline iron and clustering of slip in cadmium single crystals are considered manifestations of identical phenomena, although, in reviewer's opinion, a conclusion of this nature will be more gratifying when clustering of slip is observed in iron single crystals that exhibit a drop in load. Furthermore, recent evidence [*Inst. of Metals Bull.*, p. 58, Mar. 1952] contradicts any unique mechanism for drop in load in both single and polycrystalline iron. A. N. Holden, USA

3405. Weltmann, Ruth N., and Kuhns, P. W., Effect of shear temperature on viscosity in a rotational viscometer measurement, *J. Colloid Sci.* **7,** 3, 218–226, June 1952.

Method is suggested for analyzing temperature distribution and its effect on liquids subjected to shear in a rotational viscosimeter. Comparing calculated and measured viscosity values, authors study thixotropic behavior. The energy equation used (for stationary condition) is $\phi = -k\Delta T$, where ϕ is dissipation, k heat conductivity, and T temperature. Assuming linear stress-velocity gradient relation [AMR **5**, Rev. 1972], constant k and variable viscosity, authors obtain solution with successive approximation. An oronite polybutene oil and a silicone fluid are investigated and thixotropic breakdown is found for the latter.

Reviewer's note: The experimental values used in the paper are probably not reliable enough to make conclusions. The theoretical treatment, especially the calculation of the effective viscosity, authors' unorthodox and somewhat confusing vector notation, and their use of certain terms [AMR **5**, Rev. 2354] seem to be open to criticism. In spite of these difficulties, paper is highly recommended since it might initiate badly needed further research along similar lines. V. G. Szebehely, USA

3406. Beyer, C. E., and Towsley, F. E., The flow of polystyrene through rectangular channels, *J. Colloid Sci.* **7,** 3, 236–243, June 1952.

Spencer-Dillon flow equation for non-Newtonian liquids in circular channels [title source, **4**, 241–248, 1949] is extended by dimensional analysis to the form for rectangular channels

$$Q = C_1 P D^4/\eta_0 \, [1 + C_2 K\tau + (C_2 K\tau)^2/2! + (C_2 K\tau)^3/3! + (C_2 K\tau)^4/4!]$$

where Q is volume rate of flow, P pressure gradient, D a channel dimension, τ average shearing stress at channel wall, η_0 and K material constants, and C_1 and C_2 dimensionless parameters which are functions of the ratio of the channel-section dimensions. The equation fits flow data for a polystyrene sample within $\pm 10\%$ if the shorter channel dimension $< 0.05X$ channel length, and if the bracket expression ≤ 10.

Reviewer notes that reported values of C_1 and C_2 are meaningless without more complete definitions of D and τ.

Melvin Mooney, USA

3407. Jones, S. P., and Tyson, J. K., The rheology of a lubricating oil at temperatures below the pour point, *J. Colloid Sci.* **7,** 3, 272–283, June 1952.

Authors describe shear behavior of (a) one sample of Pennsylvania 150 neutral, dewaxed to a pour point of -15 C. at temperatures of -25 C and -30 C, and (b) a high-pour-point oil, prepared by the addition of Eastman white label grade *n*-octacosane to the above oil, at $+30$ C, in concentric cylinder viscometers.

For program (a), the cup rotates at a number of constant velocities in 40 equal increments to 400 rpm. The bob is attached to a torsion spring. Two cups of radii 1.40 and 1.50 cm with cup-to-bob clearances of 1.0 and 2.0 mm, respectively, have been employed. Under steady-state conditions, temperature control of ± 0.25 C was obtained. At high rates of shear, the degree of control was estimated at ± 0.5 C. For program (b), a modified Stormer viscometer was used with shearing stresses varying from 65 to 177 dynes/cm^2.

For (a), differences in behavior are observed that may be in-

strumental effects, although authors think that two different phenomena are involved: (1) An irreversible breakdown in the initial rigid structure of the oil, and (2) a reversible apparent thixotropy predominant at high rates of shear. Calculated temperature effects due to frictional heating account for a large part, though not all, of (2).

System (b) exhibits progressive increase in fluidity with the work done in shearing. R. Schnurmann, England

3408. Markwood, W. H., Jr., and Spurlin, H. M., Residual stresses and strains in molded plastics, *J. Colloid Sci.* **7,** 3, 244–252, June 1952.

A descriptive account of the viscoelastic flow and molding behavior of ethyl cellulose and other plastics. At molding temperatures, ethyl cellulose is more rubberlike than cellulose acetate. Injection-molded objects exhibit local frozen-in stresses that can be modified or relaxed by reheating. The results are discussed in terms of a model in which the deformation is divided into an elastic part, a delayed elastic part, and a viscous part.

Lawrence Nielsen, USA

3409. Whitfield, H. B., and Baron, T., Application of Eyring's rate equation to viscometric data on paraplex, *J. Colloid Sci.* **7,** 3, 268–271, June 1952.

Authors determined rate of shear-shearing stress curves for Paraplex G-40 (whatever that is) at various temperatures, and fitted a flow equation derived by Eyring to the curves. Results at fixed temperature fit Eyring's equation; temperature dependence does not, according to authors. In drawing this last conclusion, authors neglect temperature variation of activation energy and dimensions of flow unit. Irvin M. Krieger, USA

Failure, Mechanics of Solid State

3410. Williams, M. L., Brittle fractures in ship plates, "Mechanical properties of metals at low temperatures," *Nat. Bur. Stands. Circ.* 520, 180–206, May 1952.

Work of the Metallurgy Division of the National Bureau of Standards on brittle fractures in welded ships is described. Factors determining the liability to brittle fracture are the presence of metallurgical notches, related to welding workmanship, structural notches, related to design and the notch sensitivity of the steel. Marked decrease in fractures starting at notches is obtained by improved welding and design. Probability of fractures starting in the plates was found to increase materially with notch sensivity (criterion the 15 ft/lb trans. temp. of Charpy V-notch specimens).

Since notches cannot be fully eliminated, low notch sensitivity is also essential. Lower C- and P-, higher Si- (up to 0.12%) and Mn contents (up to 0.60) and finer grain reduce notch sensitivity.

J. H. Palm, Holland

3411. Yokobori, T., Failure and fracture of metals as rate processes, *J. phys. Soc. Japan* **7,** 1, 122–123, Jan./Feb. 1952.

A short note supplementary to previous papers [AMR **5,** Revs. 2619, 2620], in which author derives additional formulas on basis of rate-process theory. A. M. Wahl, USA

3412. Gurevich, G. I., On the problem of the yield-point criteria (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **82,** 2, 245–248, Jan. 1952.

Author proposes a new yield-point criterion for arbitrary stress conditions and presents it in a form of differential equations for the three principal stresses and corresponding deformations. He bases them on the fundamental concepts of molecular physics and refers to his previous paper [*Zh. tekh. Fiz.* **17,** p. 1491, 1947] for the physical justification of his equations. In these the criterion for the yield point is related to the change of temperature and to the velocity of deformation. He assumes for his work the ideal elastic-plastic material.

In reviewer's opinion, the rather sketchy presentation and the introduction of few arbitrary constants make it difficult to estimate the real value of the author's ideas.

W. Sylwestrowicz, USA

3413. Bollenrath, F., and Troost, A., Relations between stress and deformation gradient. III. Notch sensitivity (in German), *Arch. Eisenhüttenw.* **23,** 5/6, 193–201, May/June 1952.

Material Test Techniques

(See also Rev. 3445)

3414. Shaposhnikov, N. A., Mechanical testing of metals [Mekhanicheskie ispítaniya metallov] (in Russian), Moscow-Leningrad, Gosud. Nauch.-tekh. Izdat. Mashinostroit. Lit., 1951, 383 pp.

There is a definite need for a book which deals with the basic and formal aspects of testing of metallic materials. The pioneers in the fields of material testing and metallurgy (such as Charpy and Mesnager in France; Woehler, Bauschinger, Martens, and Heyn in Germany; Kick and Ludwik in Austria; Davidenkov in Russia, and others) have been very active in this respect.

In recent years, however, little effort has been made to summarize the rather extensive progress in this field, and very few books have taken any notice of this development. Reviewer believes the book of Shaposhnikov is perhaps the only one published since the beginning of World War II which can claim to fill this gap and to cover the entire field of the more basic aspects of material testing.

About 200 pages are devoted to the common static tests; another 50 pages to hardness tests; dynamic and high-temperature tests are discussed on nearly 80 pages, and fatigue tests on 50 pages. Spot checks indicate that recent progress in these subjects is rather fully discussed and that the author is thoroughly familiar with both their theoretical and practical aspects. At the outset, this does not seem to conform with the fact that the work directly referred to is entirely of Russian origin. The reader familiar with the subject, however, will recognize many of the graphs as being quite familiar and obviously copied from numerous American and European publications. This, on the other hand, does not depreciate the important Russian contributions to the science of material testing and particularly those by Davidenkov and his associates, which are thoroughly discussed in the book. These are undoubtedly too little known outside of USSR.

G. Sachs, USA

3415. Hoppmann, W. H., 2nd, Experimental study of the transverse impact of a mass on a column, *Proc. Soc. exp. Stress Anal.* **9,** 2, 21–30, 1952.

Measurements were made of strain and deflection from the force of impact of a solid sphere on small columns carrying various axial loads. The results are given (1) in tabular form for stress, load, and impact velocity, and (2) by curves representing the ratio of stress at a given axial load to stress at zero axial load plotted against the ratio of axial load to the Euler load. Comparison with theory is presented. J. J. Ryan, USA

3416. Blaser, R. U., Tucker, J. T., Jr., and Kooistra, L. F., Biaxial fatigue tests on flat-plate specimens, *Weld. Res. Suppl.* 17, 3, 161s–168s, Mar. 1952.

To establish on the basis of experience the design stress of the steel employed in pressure vessels, said material has been tested in fatigue, in conditions similar to those in use.

Plates of the same thickness as those of the pressure vessels and identical conditions of outside surface were prepared. Rectangular pieces of these plates cut with oxyacetylene flame constituted the test specimens.

For the test, the specimen was supported on its four edges over a backing-plate closed by an "o-ring gasket," which allowed the entrance of liquid between both plates, specimen and backing-plate. The specimen was subjected to repeated flections by applying charges and discharges of hydraulic pressure.

Before a test, the specimen was examined by magnaflux, in order to assure the absence of defects. In this manner, cracks that appear during the test are due exclusively to the fatigue process and determine the limits of fatigue.

The stress was controlled by an AX-5 strain gage cemented on the bottom surface. Further, in one of the specimens a complete strain analysis was carried out on the inside and outside surface with SR-4 rosette strain gage; also with brittle lacquers. The analysis included the determination of the deflection by a five-dial gage rack. The result of analysis of stress agreed well, in the opinion of authors, with the theoretical values given by Timoshenko and Lessells for plates supported at their four edges. Several results are shown that confirm this.

S. A. Delpech, Argentina

Mechanical Properties of Specific Materials

(See also Revs. 3378, 3395, 3401, 3408, 3409, 3410, 3442, 3443, 3561)

3417. Jenkins, W. D., and Digges, T. G., Effect of temperature on the tensile properties of high-purity nickel, *J. Res. nat. Bur. Stands.* 48, 4, 313–321, Apr. 1952.

Tension tests were made at temperatures ranging from −320 to 1500 F on high-purity nickel in the annealed condition. Exceptions to the usual trend exhibited by metals of decreasing strength and increasing ductility with increasing test temperature were observed and discussed. Strain-aging occurred in specimens tested in the temperature range of about 80 to 300 F, but recrystallization and recovery predominated in specimens fractured at 1200 and 1500 F. From authors' summary

3418. McLean, D., Creep processes in coarse-grained aluminum, *J. Inst. Metals* 80, 507–519, 1951–1952.

A specimen of super-pure aluminum was extended under a constant load of $\frac{1}{2}$ ton/in.^{2} at 200 C to fracture, which occurred at 65% extension in 850 hr. Observations were made of slip-band and grain-boundary movements on a previously polished surface. The movements were measured, mainly by means of an interference microscope, and their respective contributions to the creep extension calculated. They accounted for only about one half of the total extension. It was thought that fine slip, not easily detectable, and viscous flow due to stress-directed diffusion might be responsible for the missing creep, and examination was made with the phase-contrast and the electron microscopes. Fine slip took place in the early stages, and both processes occurred in the later stages as part of the polygonization by which the original crystals broke down into subcrystals, and which can be regarded as a combination of fine slip and a type of viscous flow. Other evidence indicated that no viscous flow unrelated to the crystal structure occurred. The extension attributable to fine flip was calculated from the tilts between neighboring subcrystals and was found to be of the same magnitude as the missing creep. Therefore, deformation occurred by easily visible slip, by grain-boundary displacement, and by fine slip, the sum of the individual contributions being of the same magnitude as the measured extension; there was no evidence of any other important process.

From author's summary by Aris Phillips, USA

3419. Greenough, G. B., Bateman, Catherine M., and Smith, Edna M., X-ray diffraction studies in relation to creep, *J. Inst. Metals* 80, 545–550, 1951/1952.

To investigate a hypothesis regarding the mechanism of creep put forward by Greenough and Smith [AMR 4, Rev. 674], two aluminum-silver alloys, one a solid solution and the other containing a precipitate, were examined. While the former behaved in the same manner as pure aluminum and showed marked cell development during creep, the latter exhibited no traces of such cells. Experiments were also carried out on the recovery of specimens quickly pulled at either 20 or 300 C. It was confirmed that, whereas annealing at 300 C in the absence of stress caused little recovery, cell development occurred if the specimens were allowed to creep at this temperature. The cell development did not become apparent until the creep strain was appreciable; the influence of the strain rate appeared to be small.

It is considered that the ideas based on dislocation theory and polygonization provide a simple explanation of the experimental results and are more satisfactory than an explanation in terms of boundary micromovements. From authors' summary

3420. Harris, W. J., The influence of shot peening on the fatigue properties of steel, *Metallurgia, Manchr.* 45, 272, 299–300, June 1952.

Test results are given to show under what condition shot-peening improves fatigue strengths of steel alloys. It is found that if the ratio of the endurance strength to the ultimate tensile strength of surface fibers was less than 0.45 to 0.50, shot-peening improves fatigue strength. Joseph Marin, USA

3421. Hartman, A., Investigation of notch sensitivity of 24S-T and 75S-T Alclad under pulsating tensile load (in Dutch), *Nat. LuchtLab. Amsterdam Rap.* M.1819, 7 pp., 4 tables, 6 figs., Jan. 1952.

Results are given of fatigue tests with 24S-T and 75S-T Alclad (thickness 2 mm). Unnotched and notched bars were compared. Bars were tested in tension only, the load pulsating between zero and a varying maximum value. The theoretical stress-concentration factor of the notched bars was 5 (computed from Neuber's nomograms).

For the unnotched bars, both materials proved equivalent at fatigue lives of 5×10^5 cycles, the loads being 18.0 and 17.8 kg/mm^2, respectively. At 5×10^7 cycles, 24S-T was found to be superior, the loads being 13.5 kg/mm^2 for 24S-T and 11.9 kg/mm^2 for 75S-T. For the notched bars, both materials were equivalent at 3×10^5 cycles, the effective stress-concentration factors being 2.8 and 2.6, respectively. For high fatigue lives (3×10^7 cycles), however, 24S-T was now found to be inferior, the loads being 4.1 and 4.8, respectively. This difference between notched and unnotched bars is explained by the fact that the effective stress-concentration factor for 75S-T was found to be constant throughout the range between 3×10^5 and 3×10^7 cycles, whereas for 24S-T, this factor increases from 2.8 up to 3.3. This is in qualitative agreement with earlier fatigue-bend tests on the same materials (report M. 1612). Quantitative agreement, however, is poor. Author emphasizes that the statistical significance of the differences found is not high enough to justify

quantitative conclusions. A more extensive investigation remains necessary. J. H. van der Veen, Holland

3422. Fisher, J. C., A criterion for the failure of cast iron, *ASTM Bull.* no. 181, 74–75, Apr. 1952.

A current theory of fracture (Zener) suggests that plastic flow invariably precedes the fracture of metals. Brittle metals such as cast iron would thus be presumed to break as soon as the first few slip bands appear, the stress system at fracture evidently being that required to initiate flow. The plastic flow of cast iron is analyzed by using the distortion-energy yielding criterion, $(S_1 - S_2)^2 + (S_2 - S_3)^2 + (S_3 - S_1)^2 = 2S_0^2$, and modifying it to account for tensile stress concentration ($K = 3.2$) at the edge of graphite flakes which are assumed to be ellipsoids of revolution. The yield curves are calculated for biaxial stress conditions and compared to experimental data of Grassi and Cornet, who used cast-iron tubes under a biaxial state of stress. For stress combinations that can be compared, author concludes there is a striking agreement between experimental points for brittle fracture and the curves for the modified flow criterion. It should be noted that only the condition of uniform nominal stress distribution is considered and that propagation of yielding is not discussed. W. Leighton Collins, USA

3423. L'Hermite, R., and Grieu, J.-J., Recent experimental studies on shrinkage of cements and concretes (in French), *Ann. Inst. tech. Bât. Trav. publics* **5**, 52/53, 491–511, Apr./May 1952.

Paper is one of a group published since 1947 on shrinkage of cement and concrete. Empirical relationships are obtained for the loss of water from cement and concrete specimens, and this loss is related to shrinkage of specimens. Relations take account of swelling of specimens when immersed in a large excess of water, and results suggest that the shrinkage, measured relative to initial dimensions of specimen, is constant for any one material and humidity of surroundings, and independent of the time of curing in water before being placed in air.

It is shown that the time for cracking of similar specimens of cement paste cast around a rigid center is independent of the size of the specimen. Influence of calcium chloride and membrane curing is also studied.

Paper is an important basic study of shrinkage problems but is not as fundamental as work of T. C. Powers and T. L. Brownyard [*P.C.A. Bull.* 22, 1948, "The physical properties of hardened cement paste"]. Results are of limited application since all work was carried out at constant temperature and no large difference in size of specimens was considered.

Theory proposed differs from that of Pickett, quoted by Powers and Brownyard, in that water held loosely in capillaries in cement paste is assumed to be negligible.

Frank A. Blakey, Australia

3424. Bergström, S. G., Stable concrete mixes, *Swedish Cem. Concr. Res. Inst. Bull.* 24, 32 pp., 1951.

Deformability measurements can be used to make sure that concrete does not segregate during conveyance and consolidation. This requires that the concrete mix shall be rendered stable, i.e., that its deformability shall remain constant during a reasonable period of consolidation. If the deformability decreases as the period of consolidation becomes longer, this implies segregation which involves the risk of inhomogeneity and areas of weakness in the finished structure. Furthermore, segregation can impair the resistance to frost action and the water tightness of concrete. A marked increase in deformability indicates poor workability, and hence involves the risk of reduction in quality because of inadequate compaction. Various methods of stabilizing concrete mixes are discussed and are illustrated by examples derived from practical applications. Additions of resins causes an increase in deformability, the composition of the mix being equal in other respects, produces stabilization, and improves the workability. This is also demonstrated by examples.

From author's summary

3425. Kühne, H., and Vodoz, J., Shrinkage and swelling of some Swiss wood species (in German), *Eidgenöss. MatPrüfAnst. Ber.* **179**, 29–44, Dec. 1951.

Detailed data are presented in tabular and graphical form on the dimensional instability of Swiss spruce, fir, larch, beech, and oak within the range from beyond fiber-saturation point to oven-dry condition on the basis of tests on small clear specimens of different-density sapwood or heartwood. Results of shrinkage tests parallel to grain differed when different testing methods were employed. A detailed 76-item bibliography is attached to the paper. E. G. Stern, USA

3426. Kühne, H., Investigation of some characteristics of ash and black locust wood with special consideration of their use for tool handles (in German), *Eidgenöss. MatPrüfAnst. Ber.* **179**, 1–28, Dec. 1951.

Complaints concerning frequent failures of tool handles led to a thorough investigation of unsatisfactory handles and systematic comparative tests on the physical and mechanical properties of the most frequently used tool-handle woods, i.e., ash and locust.

The test data are presented and correlated graphically. Results are interpreted for achieving decreases in tool-handle failures stressed in static bending and in impact bending. In doing so, emphasis is given to the importance of straight grain, with a 5° deviation resulting in as much as a 40% decrease in impact strength. Furthermore, the annual rings should be parallel with the bending plane; high specific gravity is desirable; width of annual rings of less than one millimeter is undesirable. Preference for the use of locust to ash is expressed.

The experience of other authors, that such ash as is sensitive to impact bending can hardly be eliminated by macroscopic inspection, has been stated again, even if the material is classified by its density, annual growth, color, light reflection, and coloration after treatment with chemicals.

The report is supplemented by some thoughts and comments on broken tool handles. E. G. Stern, USA

3427. Kitazawa, G., Young's modulus of elasticity of small wood beams by dynamic measurements, *For. Prod. Res. Soc.* Prepr. 225, 4 pp., June 1952.

Paper is concerned with the correlation between dynamic and static moduli in flexure and the influences of moisture content and grain angle on the dynamic modulus of 2 × 2 × 30-cm test specimens from five wood species, put under vibration by means of an electro-acoustic vibrator driven by a variable-frequency audio oscillator. Summaries of the test data obtained are presented graphically. E. George Stern, USA

3428. Northcott, P. L., The development of the glueline-cleavage test, *For. Prod. Res. Soc.* Prepr. 223, 9 pp., June 1952.

Efforts to reduce the variability encountered in testing wood-to-wood bonds and a new method of testing glue lines are described. This new method is compared with three standard methods of test and is found to be the most suitable of the tension-normal-to-the-glue-line, tension-shear, block-shear, and glueline-cleavage tests when used to evaluate the quality of the bond between Douglas fir veneers and phenolic-resin adhesives.

From author's summary by E. G. Stern, USA

3429. Lamb, J. L., George, D. A., Baker, H. A., and Sieffert, L. E., Impact strength of some thermosetting plastics at low temperatures, *ASTM Bull.* no. 181, 67–70, Apr. 1952.

Paper gives Izod impact values for five types of laminates and four types of thermosetting molding compounds. These values were obtained for 0, −23, −40, and −55 C and were stored for 1 day, 1 week, 2 weeks, and 7 weeks prior to testing. No effect of time of storage at low temperature on the impact strength was observed. Joseph Marin, USA

3430. Ishihara, A., Hashitsume, N., and Tatibana, M. Statistical theory of rubber-like elasticity. V. The stress birefringence, *J. appl. Phys.* **23,** 3, 308–312, Mar. 1952.

The effects of network formation of non-Gaussian chains on the stress birefringence are calculated. If the birefringence is plotted against the stress, the effects make the curve deviate from a straight line. When it is plotted against the elongation, the curve will rise above that corresponding to independent Gaussian chains, in agreement with the experiments.

From authors' summary by R. G. Boiten, Holland

3431. Blanchard, A. F., and Parkinson, D., Breakage of carbon-rubber networks by applied stresses, *Indust. Engng. Chem.* **44,** 4, 799–812, Apr. 1952.

A semiempirical force-elongation function is derived which expresses stretching force in terms of parameters G, the modulus, and μ, a shape factor significant at high elongation where force rises rapidly. Experimental data show reduction in G is proportional to total remaining cross links, including those formed by rubber-carbon bonds. Dimensional analysis then shows $X = S/G^{2/3}$, where X is bond stress at bond rupture under prestress S at relative length α, G is modulus after prestress. Data indicate large number of C-rubber bonds of small X, small number of bonds of large X. Nearly all C-rubber bonds are broken at highest prestress. Heat treatment in mixing process produces cured stocks with increased number of bonds of high X. Strong filler-rubber bonds are found only with carbon blacks; distribution of weak bonds with other fillers are independent of chemical nature of filler.

Reviewer's comment: This otherwise excellent article suffers from the unwarranted tacit assumption that, in a given state of sample stress, all bond stresses are equal. Authors' reported distribution of bond strengths may be due largely to a wide distribution of bond stresses. Melvin Mooney, USA

3432. Lang, W. R., Wool fibre contour: its significance to the mechanical properties of the fibre, *J. Text. Inst. Proc.* P245–P251, May 1952.

Author refers to an impression in the wool industry that the degree of ellipticity of the cross section of a wool fiber affects its manufacturing behavior. He refers to more recent authors who contend that this is not important. He indicates that the ratio of major to minor axis rarely exceeds the range of 1 to 2, and proves that the effect on tensile, torsional, and bending properties of wool is insignificant in comparison with the effects of mean diameter distribution and moisture content on these properties.

Rogers B. Finch, USA

3433. Bechmann, R., and Parsons, P. L., Mechanical strength of piezoelectric crystals, *Brit. J. appl. Phys.* **3,** 5, 147–150, May 1952.

A direct mechanical method and an electrical method have been used to determine the mechanical strength of the piezoelectric materials sodium chlorate, sodium bromate, ammonium dihydrogen phosphate, ethylene diamine tartrate, and lithium sulphate monohydrate. New measurements have also been made on quartz as a check on the methods. A formula for the current due to the piezoelectric polarization is given which covers the longitudinal flexural, contour, and thickness modes of vibration considered. The maximum safe current for piezoelectric resonators has been calculated for specific cuts of the various materials.

From authors' summary

3434. Vajta, M., Self-annealing of overhead conductor materials under the continuous action of heat, *Acta Techn. Hung., Budapest* **1,** 3, 277–297, 1951.

Author reports results of studies of effect of short- and long-time heating on tensile strength of Hungarian overhead conductor-wire materials up to 2.8 mm in diam. Information is of interest in power applications where heating may result from deicing, short circuits, and temporary overloads.

Wires made from aluminum, copper, bronze, cadmium copper, and an aluminum alloy having diameters of 1.8 and 2.8 mm were heated to temperatures between 70 C and 135 C for varying periods of time up to 180 days. The effect of these treatments on tensile strength is reported. Tabulated data are given showing calculated maximum admissible temperatures for seven conductor materials under five different conditions of overload.

C. A. Keyser, USA

3435. Krivobok, V. N., Properties of austenitic stainless steels at low temperatures, "Mechanical properties of metals at low temperatures," *Nat. Bur. Stands. Circ.* 520, 112–136, May 1952.

Author presents a summary of the available knowledge on the mechanical properties of austenitic stainless steels at subzero temperatures. Information previously available is supplemented by new data from the laboratories of the author's company. Data on tensile properties, notch toughness, and fatigue are presented along with discussions of the effects of cold working on these properties. The effects of heat treatment, especially treatments likely to result in carbide precipitation or sigma phase formation, are described. Data are presented to illustrate that the distribution of strain in a stretched tension specimen is strongly dependent upon the testing temperature, and that the total elongation in two inches provides a very inadequate description of the manner in which the deformation behavior changes with temperature. Results of tests conducted at room temperature on commercial Type 304 austenitic stainless steel after prolonged exposure at −320 F show that the notch toughness at room temperature and at −320 F is not affected by exposures up to one year. W. T. Lankford, Jr., USA

3436. Fitzgerald, J. V., Anelasticity of glass: III, Effect of heat-treatment on the internal friction of tank plate glass. IV, Correlation of electrical strain with mechanical strain in glass, *J. Amer. ceram. Soc.* **34,** 12, 388–391, Dec. 1951.

Heat treatment or annealing decreases the internal-friction peak commonly attributed to sodium-ion diffusion in tank plate glass, a typical soda-lime-silica glass. The peak is shifted to higher temperatures at constant frequency of vibration or to lower frequencies at constant temperature. The activation energy for the shift is greater in the annealed glass and agrees with the activation energy for the electrical conductivity and alkali durability of annealed glass. Heat treatment also decreases the internal friction caused by elastico-viscous effects.

The residual charge and anomalous absorption current reported for certain glasses can be explained by referring to internal friction peaks caused by the stress diffusion of sodium or potassium ions. When an electrical potential gradient or "electrical

stress" is applied to any of these glasses, the "induced electrical strain" is associated with the time-consuming formation of a new equilibrium distribution of sodium ions.

From author's summary by R. G. Boiten, Holland

3437. Lillie, H. R., A method for measuring the flow point of glass, *J. Amer. ceram. Soc.* **35,** 6, 149–155, June 1952.

The viscosity characteristics of glasses are commonly represented by the temperatures corresponding to three reference viscosities. One of these, the softening point ($10^{7.6}$ poises), is suitable for measuring by routine methods, and is used for the control of composition during the melting operation. Author points out the desirability of establishing another reference point suitable for routine measurements nearer the melting range, and proposes a viscosity value of 10^5 poises, which he would call "flow point." Softening point is determined by observing the rate of elongation of a glass fiber in a special laboratory furnace. This general method is also applied to flow point, but, to obtain accuracy, a tractive load is applied which, at the viscosity considered, produces high rates of elongation of the fiber. Consequently, the equipment used involves electric controls, heater, and electronic measuring device. When properly calibrated from one or more glasses of known viscosity characteristics, the precision of the measurements is 1 C for low-melting-temperature glasses, and 5 C for high-melting-temperature glasses. Correction for infrared absorption by the specimen is required for certain glasses.

E. B. Shand, USA

3438. Futagami, T., Corrosion of glasses studied by some radio-active element as a tracer, *Mem. Fac. Engng. Kyushu Univ.* **13,** 1, 87–94, 1952.

Using uranium for an isotope, this experiment is done for a preliminary test of the corrosion of glasses, using a radio-isotope as a tracer. The accuracy of a G-M counter, back-scattering of vessels, self-absorption of the glass, and chemicals which are used for this purpose are investigated. The corrosion rate of 10% NaOH solution for uranium glass is about 0.024 mg/cm²-h under 100 C. The accuracy of this method is the same order with the balancing method, but far more convenient.

It is concluded that, for an ordinary corrosion test, 5×10^{-2} mc of some radio-isotope for one kilogram of tested glass may be needed.

From author's summary

3439. Smith, R. L., Moore, G. A., and Brick, R. M., Mechanical properties of high-purity iron-carbon alloys at low temperatures, "Mechanical properties of metals at low temperatures," *Nat. Bur. Stands. Circ.* 520, 153–179, May 1952.

Work focuses on the tensile properties after it is pointed out that they offer a better chance to analyze low-temperature behavior than do the data obtained in the notched-bar test. Pointing out, too, that most of existing notched-bar data were obtained for commercial steels in which the many metallurgical variables were not precisely controlled, authors investigate four steels which they carefully prepare. Carbon in these varied from 0.05 to 0.49%. Microstructures had ASTM No. 4-5 ferrite grain size and pearlite of spacing equivalent to normalized steels. With novel experimental equipment, true-stress natural-strain data were produced for the range of temperatures from 23 to −185 C. Among more important results are the increase of upper and lower yield point, flow stress, and fracture stress with increase in carbon content and decrease in temperature. The fracture stress, however, dropped sharply in value from −150 C to −185 C, accompanied by a sharp loss in ductility. Comparison of data with those for low-aluminum high-purity ferrites indicated that carbon reduces the ductility of iron at all temperatures in range investigated. Although some of these results have been shown before, reviewer believes that the experimental care and well-controlled materials involved make this an important contribution.

Julius Miklowitz, USA

3440. Johnson, J. B., and Shinn, D. A., Application of metals in aircraft at low temperatures, "Mechanical properties of metals at low temperatures," *Nat. Bur. Stands. Circ.* 520, 97–111, May 1952.

The lowest temperature that modern aircraft will encounter is approximately −130 F. Since the extremes of low temperatures occur at high altitudes in a fluid medium, serious shock loadings are unlikely unless the metal is subjected to ballistics or explosive impacts. Considerable data on tests of aircraft metals at temperatures down to −420 F are presented. These metals showed good low-temperature properties, which is confirmed by the fact that no failures attributable to change in mechanical properties of the materials have been reported from operating stations in cold climates. Most failures due to low temperatures are caused by unequaled contraction of unlike materials producing galling or binding, with subsequent overstress and distortion or failure. The use of the notched impact test as the sole criterion of ductility is questionable, unless service failures of components can be correlated with the impact values. The change in ductility in a tensile test is more informative and subject to better interpretation by an engineer. The evaluation of metal for low-temperature serviceability requires more extensive data.

J. Neils Thompson, USA

3441. Fisher, W. A. P., Cross, R. H., and Norris, G. M., Pretensioning for preventing fatigue failure in bolts, *Aircr. Engng.* **24,** 280, 160–163, June 1952.

The prevention of fatigue in bolts by controlled pretensioning is investigated theoretically. It is shown that the effect of pretension is to reduce the alternating load in the bolt and that the stiffness of the fitting plays an important part in this reduction. Fatigue tests on 3/4-in. B.S.F. bolts with various amounts of pretension show how this reduction in alternating load can prevent fatigue failure. A warning is given against relying on the benefits of pretensioning without insuring that pretension is maintained in service.

From authors' summary

Mechanics of Forming and Cutting

3442. Bartocci, A., Notes on transverse mechanical properties of forgings (in Italian), *Metallurgia ital.* **42,** 8/9, 289–296, Aug./Sept. 1950.

Heavy or important forgings are tested by taking transverse test specimens from them. Transverse quality characteristics are very sensitive to the influence of various causes, not always identified. The article covers a report on the examination, carried out on the basis of statistical data, for special heat-treated steels, of the influence on such characteristics of various factors (dendrite, shape of ingots, forging diagram, manufacturing in the electric basic or acid open-hearth furnace).

From author's summary

3443. Schauss, R. P., Baley, R. F., and Woodliff, E. E., A study of factors affecting molding sand density, shrinkage, expansion and workability, *Trans. Amer. Foundrymen Soc.* **58,** 217–225, 1950.

In order to gain a better understanding of the mechanics of foundry sands, their effects upon moldability and casting quality, authors undertook a study of sands bonded with five common clay-type binders.

Results of the investigations show rammed density of molding sand to be affected by the type of clay bond and the amount of clay substance.

Included in the investigation are results of testing sands at constant density ramming. This not only suggests a new method of testing molding sands, but enables one to measure the relative energy of ramming for different types of sands and binders.

The study includes results of tests for free and confined expansion. The results of using machined carbon specimen tubes in which the specimen is rammed for confined expansion are explained. A relationship was established between these high-temperature properties and clay contents.

From authors' summary

3444. Rutherford, N. B., The effect of metal/mould reaction on 85:5:5:5 leaded gun-metal sand castings, *J. Inst. Metals* **80,** 555–568, 1951/1952.

Earlier work had shown that the controlled absorption of gas arising from metal/mold reaction improved the strength and pressure-tightness of phosphor-bronze or gun-metal sand castings having marked heat centers. The present work was designed to examine further the effect with leaded gun metals, in view of their increasing popularity as casting materials.

Varying degrees of metal/mold reaction were induced in 85:5:5:5 leaded gun metal by casting it into green-sand molds from four pouring temperatures between 1050 and 1200 C, and by varying the residual phosphorus content from 0.002 to 0.15%. The castings were in the form of ribbed plates, 1/4, 1/2, and 1 in. thick, and 1- and 2-in.-diam bars. The plates were intended to simulate poorly fed industrial castings.

The amount of gas arising from metal/mold reaction that was absorbed was calculated from the densities of the castings. Its effect on the properties was determined from tensile test pieces. The work was designed as a factorial experiment, and the results were examined by statistical methods, details of which are given in an appendix. Concurrently with the laboratory work, trials were run in two foundries making valve castings in 85:5:5:5 gun metal.

It was concluded that the value of metal/mold reaction as a means of increasing the proportion of pressure-tight castings is less with leaded gun metal than with phosphor-bronze or lead-free gun metal. With 85:5:5:5 leaded gun metal it may be used with advantage where the rate of solidification is rapid, as in castings with section thicknesses of the order of 1/4 in., or in thicker-section castings poured from temperatures lower than 1100 C. From author's summary

3445. Signora, M., and Testero, G., A method for rapid investigation of the structure of large ingots by explosive charge (in Italian), *Metallurgia ital.* **64,** 5, 180–183, May 1952.

Article describes a rapid investigation method which, utilizing an explosive charge as dynamic stress, allows the testing of the fracture surface obtained according to the intermediate longitudinal section of heavy steel ingots.

A report is given of the first series of tests carried out for the purpose of experimental design with details of the modalities used, and of a further test carried out on a larger number of ingots.

From the tests carried out it is shown that the results obtainable with this method are altogether provable and, by a rapid and economic investigation, it is possible to give a clear idea both of the primary structure and compactness of the ingots and of the presence of probable internal anomalies.

From authors' summary

Hydraulics; Cavitation; Transport

(See also Revs. 3405, 3478)

3446. King, G. W., Monte-Carlo method for solving diffusion problems, *Indust. Engng. Chem.* **43,** 11, 2475–2478, Nov. 1951.

Since the asymptotic expression of the probability density of a random walk satisfies the diffusion equation, author describes the problem of random walk by the Monte-Carlo method in computing machines, and shows the applications of solving the diffusion problems. The method is applied to problems of diffusion with reflecting or absorbing barriers, and diffusion with chemical reactions. Furthermore, author indicates that the difficult problem of the configurations of long-chain molecules can be considered as a problem of diffusion with excluded volumes.

C.-M. Tchen, USA

3447. Carr, J. H., Long-period waves or surges in harbors, *Proc. Amer. Soc. civ. Engrs.* **78,** Separ. no. 123, 16 pp., Apr. 1952.

Paper reports results of field and model studies of sources and characteristics of long-period waves in harbors, and analyzes basin resonance and water motions induced by waves. By long-period waves, the author means those with periods of from 1 to 12 min or more, as distinguished from usual waves of 8 to 20-sec periods. It is shown that models are particularly adaptable to this type of study, and examples of their use in the design of harbor facilities are given. Even when restrained by heavy tackle, moored ships have shown longitudinal and transverse drift amplitudes up to 10 ft, snapping mooring lines, breaking piles, and damaging the ships themselves. Harbors should be so designed that the periods of resonance are different from the periods commonly present in the incoming waves. There are certain locations in a harbor, corresponding to the loops in the vertical vibrations, where the horizontal vibration is a minimum, and ship outfitting can be best carried on. Author believes that studies should be made of the natural period of oscillation of moored ships, as determined by the mass of the ship and the elasticity of the mooring system. It would seem to the reviewer that the latter might be so adjusted as to avoid most of the difficulty.

Ralph W. Powell, USA

3448. Dorman, R. G., The atomization of liquid in a flat spray, *Brit. J. appl. Phys.* **3,** 6, 189–192, June 1952.

The investigation deals with the formation of flat sprays produced by agricultural nozzles with water, and kerosene, at differential pressures in the range of 45 to 105 psia. Spark photography was used in the study of spray development. Drop-size distribution was determined from patterns made on filter paper by dyes added to the sprayed liquid.

The Nukiyama-Tanasawa equation was used to determine the Sauter mean diameter. A new diameter, designated D_g, the value of the 99.99% number was introduced. This and the Sauter mean diameter were found to be related to the volume of liquid sprayed in unit time, spray angle, surface tension, liquid density, and pressure differential. Influence of viscosity was considered negligible. The two diameters may therefore be predicted.

It was concluded that the drops are formed according to the Castleman ligament theory. Extreme care was exercised to assure still air and high humidity during the tests. However, "the nozzle was carried smartly across the layout, spraying horizontally and pointing down the line." Reviewer believes that this procedure nullifies the use of the experimental data in the derived equations, since the pressure differential is no longer related to the velocity of the spray relative to still air.

H. A. Einstein, USA

3449. Bouvard, M., and Molbert, J., Graphical method for the calculation of surge tanks (French and English), *Houille blanche* **6**, 3, 356–371, May-June 1951.

In this article [see also AMR **5**, Rev. 159], authors have shown that a very simple graph can solve all the problems of surge-tank oscillations. The concept of the "accelerating head"—difference of height between the actual water level in the tank and the nominal water level which would occur in a permanent regime where the same discharges would be used—and the graphical solution, together with the various equations governing the water motion, make it possible to rapidly determine the oscillations taking place in the most complicated installations.

Authors show that, through procedures called "direct" and "retrograde," once the over-pressure maxima have been established, either the optimum dimensions of a surge tank or the operations possible in a given tank can be found. A number of variables are surveyed. Finally, the method is applied to some quite complicated cases involving several surge tanks placed in series, Y-tunnels, etc. Various diagrams worked out according to this method prove to be of great help for all the problems where wave phenomena are unimportant.

P. Alexandre, France

3450. Jorissen, A. L., and Newton, H. T., Discharge measurements by means of cylindrical nozzles, *Trans. ASME* **74**, 5, 825–835, July 1952.

The purpose of the tests described was to establish coefficients for a measuring device, the values of which would remain constant for lower values of the Reynolds number than was possible with the so-called standard measuring devices such as the Venturi tube. Tests with water were run on cylindrical nozzles having diameter ratios β varying from 0.2224 to 0.6928, and with length ratios varying from 0.982 to 2.854. Authors conclude that the nozzle will have a constant coefficient for much lower Reynolds numbers than the Venturi tube. However, the comparison is not as favorable as implied, since the authors use a Reynolds number that is based on inlet conditions, while the ASME report (their Ref. 1) used a Reynolds number that was based on the throat section. This produces a marked difference at the small β ratios. The head loss was greater than the throat velocity head for the small diameter ratios, and was less than the throat velocity head for the large values of β. Glen N. Cox, USA

3451. Robertson, J. M., and Ross, D., Effect of entrance conditions on diffuser flow, *Proc. Amer. Soc. civ. Engrs.* **78,** Separ. no. 141, 24 pp., July 1952.

Authors conduct experimental investigation of the flow conditions in conical diffusers (diameter at the entrance $D = 6$ in., total angles $\beta = 5°$, $7\frac{1}{2}°$, and $10°$), preceded by relatively short lengths of straight pipe (L = 2-, 5-, and 9-diameter lengths). Measurements are taken of pressure distribution along the diffusers and velocity traverses at different sections. The area ratio of the diffuser is the major geometric parameter governing the shape and extent of the boundary layer. The most important factors determining the flow are the angle β and the extent of the boundary layer at the entrance, given indirectly by the length-diameter ratio L/D. The pressure efficiency is a function of the product $\beta L/D$. The energy efficiency decreases with increasing area ratio, but is practically independent of β and entrance conditions. As some of the velocity traverses suggested the occurrence of separation near the end of the diffuser, authors determine the critical values of different parameters and develop methods for estimating the values of these parameters in any diffuser. The study should enable the design of diffusers in which occur the type of entrance conditions studied.

From authors' summary by Alb. Schlag, Belgium

3452. Crausse, É., Pouzens, G., and Cachon, P., Contribution to the study of bottom gates (in French), *C. R. Acad. Sci. Paris* **234**, 26, 2521–2523, June 1952.

In this latest article on this subject (see AMR **5**, Revs. 3127, 3128) authors compare theoretical results from graphic computation of energy and momentum specific equations with experimental work in a rectangular flume, for constant rate of flow or upstream head conditions, respectively.

Good agreement is observed between both series of values, which proves particularly the validity of hypothesis about loss of head in the jet flow. Armando Balloffet, Argentina

Incompressible Flow: Laminar; Viscous

(See also Revs. 3296, 3406, 3447, 3448, 3523, 3529)

3453. Dolapchiev, Bl., Stability of vortex streets (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **78**, 2, 225–228, May 1951.

In the present paper, previous mathematical analysis by the same author is amplified and extended concerning a special case of nonsymmetrical vortex streets, namely the staggered twin-row arrangement of vortexes (like the Kármán street) which moves obliquely with respect to the surrounding fluid. This particular motion, which as yet has not been observed in nature nor in the laboratory, was shown in a previous paper by the author to be theoretically stable. In the present paper, the motion of the street as it approaches an obstacle is studied by using "group-displacement" technique and by establishing path trajectories of the individual vortexes.

Author finds that the motion of each vortex in the context of the configuration of the street appears to be stable in each phase of its path, and that all vortexes of the street move in a pattern resembling the chessboard arrangement. J. R. Weske, USA

3454. Coddington, E. A., The stability of infinite differential systems associated with vortex streets, *J. Math. Phys.* **30**, 4, 171–199, Jan. 1952.

This paper marks the first time that the stability of the vortex street has been treated in terms of the full infinite system of equations for the small displacements. Before entering into the hydrodynamical stability problem, author considers a class of infinite systems of differential equations of the form (*) $\dot{\zeta} = A\zeta$, where A is an infinite constant matrix with certain prescribed properties, and $\zeta = \zeta(t) = (\zeta_n(t))$, $n = 0, \pm 1, \pm 2, \ldots$, is an infinite vector with k-dimensional vectors $\zeta_n = (\zeta_n{}^i)$, $i = 1, \ldots, k$, as elements. After constructing explicitly the solution of the initial value problem for (*), he establishes stability criteria for the solutions, formulated in terms of the Hilbert norm $||\zeta|| = (\Sigma_{n=-\infty}^{k} \Sigma_{i=1}^{k} |\zeta_n{}^i|^2)^{1/2}$, these criteria being quite analogous to those known for finite systems. For a vortex street, the infinite system of linearized equations obeyed by the small displacements from equilibrium belongs to the class of equations (*) with $k = 4$. The author is thus able to draw conclusions concerning stability of the vortex street, where stability is, of course, understood with respect to initial displacement vectors of finite norm. For a street with vortexes situated (in equilibrium) at the points $(2nb + c, a)$, $(2nb - c, a)$, $n = 0, \pm 1, \pm 2, \ldots$, he shows that if $q = c/b \neq \frac{1}{2}$ there are initial displacement vectors of finite norm for which $||\zeta(t)||$ becomes infinite exponentially as $t \to \infty$, so that the street is unstable. This is, of course, in agreement with von Kármán's classical result. For the case $q = \frac{1}{2}$, a necessary condition for stability is (**) $\cosh^2 \pi a/b = 2$, again in agreement with the classical theory. However, author shows by counterexample that even when this condition is satisfied there

are initial displacement vectors for which $||\zeta(t)|| \to \infty$ faster than t^β as $t \to \infty$ for any $\beta, 0 < \beta < 2$. This contradicts the well-known stability criterion for the Kármán street which, we recall [Lamb, "Hydrodynamics," 6th ed., Cambridge, 1932, pp. 225–229], is proved in a different sense from that of the present paper and for only a restricted class of allowed initial displacements (which, in addition, have infinite norm and are therefore not admitted in the present discussion). The author shows further, as have several authors [see, e.g., Goldstein, "Modern developments in fluid dynamics," 2, Oxford, 1938, pp. 563–564], that even in Kármán's sense, the vortex street is unstable with respect to arbitrary initial disturbances. However, he displays a wide class of finitely normed initial displacements for which the Kármán criterion (**) is sufficient, as well as necessary, for stability. The paper concludes with a detailed discussion of the stability of the double vortex street.

Courtesy of Mathematical Reviews D. Gilbarg, USA

3455. Allen, H. J., and Perkins, E. W., A study of effects of viscosity on flow over slender inclined bodies of revolution, *NACA Rep.* 1048, 13 pp., 1951.

Supersedes paper reviewed in AMR 4, Rev. 1281.

3456. Broszko, M., On the fundamental assumption of the equations of laminar movement, *Arch. Mech. stos.* **2**, 2, 139–146, 1950.

Author shows that the equations of fluid motion derived by Stokes on the basis of a Newtonian fluid with velocity components u, v, w may be obtained by considering each component, say u, composed of a principal or measurable movement $\bar{u}$ plus a fluctuating (secondary) part u'. Problem is solved by considering transfer of impulse analogous to the same process which must occur in diffusion of matter and transfer of heat. Reviewer does not believe that author has removed the empirical nature of the Newtonian fluid hypothesis, but has related it to the corresponding hypotheses in the heat- and mass-transfer mechanisms.

Paul R. Trumpler, USA

3457. Polyakhov, N. N., Flow around cascades of given form (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **84**, 2, 233–236, May 1952.

Author develops a method for calculating cascades of given profile form and given stagger angle for arbitrary gap distances. The method is based on a stepwise conformal transformation of a cascade of ovals, generated by an infinite set of dipoles along the y-axis, into the given cascade. The first step is a transformation of the cascade of ovals into one of plates at a stagger angle $\pi/2$. This latter is then transformed into a similar one at an arbitrary stagger angle β, using a formula first given by N. E. Joukowsky. All these auxiliary transformations may be tabulated, so that in using this table the calculation of a profile cascade differs only slightly from that of an isolated profile.

W. Wuest, Germany

3458. Hahnemann, H. W., Contours of free discharge jets and their technical applications (in German), *Forsch. Geb. Ing.-Wes. (B)* **18**, 2, 45–55, 1952.

Author considers a jet issuing from a slit of an infinite boundary into unlimited space, the boundary being symmetrically inclined at various angles and the fluid being assumed ideal. Using conformal transformation, the free streamlines and the coefficients of contraction are obtained. The analogous axially symmetric case and the effect of limiting the space into which the jet is discharged are also discussed. Useful numerical results are given.

Chia-Shun Yih, France

3459. Knudsen, J. G., and Katz, D. L., Velocity profiles in annuli. I. Correlation of experimental data. II. Applications to computation of heat transfer, Proc. Midwest. Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 175–2 951. 810.

Authors attempt to correlate experimental data for velocity profiles in annular flow passages with and without heat transfer at several Reynolds numbers. The description of the testing technique is confusing and incomplete. In particular, the impact tube used seems appropriate for measurements within 0.015 in. (tip projecting 0.030 in.) of a wall but not for midstream measurements. No conclusions regarding the meaning of the results are justified.

D. C. Prince, Jr., USA

3460. Gadd, G. E., Some hydrodynamical aspects of the swimming of snakes and eels, Phil. Mag. (7) **43**, 341, 663–670, June 1952.

Author presents idealized mathematical approach to motion of eels and swimming snakes. Two-dimensional analysis of perfect fluid is given. Excellent discussion of propulsive efficiency of slender bodies moving in a perfect fluid.

J. M. DallaValle, USA

3461. Falkner, V. M., The solution by lifting-line theory of problems involving discontinuities, *Aero. Res. Counc. Lond. Rep. Mem.* 2592, 9 pp., 15 tables, 3 figs., Oct. 1947, published 1952.

Report presents a method of determining finite-span airfoil characteristics in incompressible flow. Lifting-line theory and the usual Fourier series methods are employed. The methods originated by Multhopp are extended to apply to discontinuities in planform, angle of attack, lift-curve slope for two-dimensional flow, and chord. A unique feature is the introduction of a division of the spanwise loading and circulation distribution to symmetrical and antisymmetrical components. This permits the solution of the simultaneous equations for the Fourier coefficients to be based on points equally spaced along the semispan instead of on the usual angular measure. Several examples are given as illustrations of the method. The report is to serve as an introduction to a later more extensive treatment of lifting-plane theory.

M. J. Thompson, USA

3462. Lavrent'ev, V. M., Influence of the boundary layer on the wave resistance of a ship (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **80**, 6, 857–860, Oct. 1951 = *David W. Taylor Mod. Basin Transl.* 245, 4 pp., Apr. 1952 (Lavrentieff).

Author examines possible effect of boundary layer in producing a virtual modification of the form of ships. It is suggested that equations of modified underwater form should be written as sum of two terms, one giving true form and one boundary layer. This equation is substituted in usual wave-resistance expression. Assuming boundary-layer thickness to be a function of Reynolds number, author concludes by suggesting that wave resistance is influenced by scale effect.

A fuller examination of the same problem has been given by Havelock [*Trans. Instn. nav. Arch.* 90, 259–266, Mar. 1948].

J. K. Lunde, Norway

3463. Mochizuki, S., On the laminar flow in the inlet length of a circular pipe, *Mem. Fac. Technol., Tokyo metrop. Univ.* no. 2, 41–47, 1952.

Former calculations (Boussinesq; Schiller) are criticized. Author obtains a solution of the equation of motion of an incompressible, viscous fluid, fitting Nikuradse's experimental curves much better, by making a number of very flexible assumptions;

viz., $u = (1 + f)\{1 - (r^2/a^2)^{1/f}\}\bar{u}$ and $\pi_x = \pi_x(x; 0)\{1 - (r^2/a^2)^{1/m}\} + \pi_x(x; a)\{1 - (r^2/a^2)^{1/n}\}$, with $f = f(x) = u(x; 0)/\bar{u} - 1$ and $m = m(f)$; $n = n(f)$. Herein a is pipe radius; r distance from axis; x distance from entry section; u axial velocity; $u(x; 0)$ axial velocity on the axis; $\bar{u}$ mean axial velocity in the pipe section; $\pi_x = \rho^{-1}\partial p/\partial x$; ρ density; p static pressure. Author puts $m = f^3$, $n = (1.177f^3 - 0.840f^4)/(1 - f)$ which yields a rather complicated expression for dx/df; this can be approximated by $dx/df = aR\{0.0490f/(1 - f) + 0.0749f + 0.1497f^2\}$ with R Reynolds number. The inlet length L ($= x$, for which $f = 0.99$) is then found to be $0.26\ aR$. H. Wijker, Holland

3464. Wolibner, W., On the plane motion of an incompressible viscous liquid surrounding a simple closed curve (in French), *Studia Math.* **12**, 279–285, 1951.

Let C be a closed curve with continuous tangent, forming the interior boundary of a viscous incompressible fluid moving in a plane. Relative to some Newtonian frame N, C has unit velocity in a fixed direction, and the author is interested in motions of the fluid which are steady relative to C and of finite kinetic energy E relative to N. He measures velocity (u, v) relative to N, but regards the components as functions of coordinates (x, y) relative to C. [It seems to the reviewer that it would be simpler to use C as frame of reference for both velocity and coordinates, and express the energy condition by saying that $\int\int[(u + 1)^2 + v^2]d\sigma$ is finite.] Transforming to polar coordinates (r, ϕ), he obtains expressions for the components of force P_x, P_y on C; that for P_x is

$$P_x = -\iint_{H_r} \frac{\partial u}{\partial t}\, d\sigma - r^2 \int_0^{2\pi} \frac{\partial u_\phi}{\partial t} \sin\phi d\phi + F(r) \quad [*]$$

where H_r is the region between C and a circle K_r of any radius r, and $F(r)$ involves only integrals on K_r. Using the finiteness of E and Schwarz's inequality, he proves the existence of an infinite sequence of radii $\{r_n\}$ such that $\lim_{n\to\infty} F(r_n) = 0$. On making the further hypothesis that radial velocity and pressure are bounded, he proves that

$$P_x = -\lim_{n\to\infty}(D_{r_n''} + \partial E_{r_n''}/\partial t) \quad [**]$$

where $\{r_n''\}$ is an infinite increasing sequence and

$$D_r = R^{-1}\iint_{H_r}\left[\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial u}{\partial y}\right)^2 + \left(\frac{\partial v}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial y}\right)^2\right]d\sigma$$

$$E_r = \frac{1}{2}\iint_{H_r}(u^2 + v^2)d\sigma$$

(R is Reynolds number). He concludes from [*] that in a steady motion no force is exerted on C. Further, from [**], under the boundedness conditions on velocity and pressure, he concludes that no steady motion exists satisfying the requirements. This conclusion is similar to that of P. Udeschini [*Atti Accad. Italia R.C. Cl. Sci. Fis. Mat. Nat.* (7) 2, 957–963, 1941], who, however, used a boundary condition at infinity instead of the condition of finite energy. J. L. Synge, Ireland

3465. Dolidze, D. E., The unsteady motion of a viscous fluid about a cylinder (in Russian), *Soobshchen. Akad. Nauk Gruzin. SSR* **8**, 11–18, 1947.

3466. Dolidze, D. E., Unsteady motion of a viscous fluid about a sphere (in Russian), *Trudi Thiliss. Mat. Inst. Razmadze* **16**, 105–116, 1948.

Author considers the limiting behavior of the solutions for two problems of unsteady flow, the first paper treating the two-dimensional and the second the three-dimensional cases. The Navier-Stokes equations are linearized by neglecting inertial terms, but the author indicates that this is not essential. In order to insure uniqueness in each case, it is assumed that certain continuity requirements are satisfied and that $\lim_{r\to\infty} r^2 p v_i = \lim_{r\to\infty} r^2 v_i\, \partial v_k/\partial x_k = 0$, where p is pressure, v_i velocity in direction x_i, and $r^2 = \Sigma x_i^2$ [cf. Dolidze, AMR **1**, Rev. 311; **3**, Rev. 294]. The first problem is that of a circular cylinder (sphere) rotating with velocity $\Omega(t)$. Here it is shown that with $\Omega(0) = 0$, $\lim_{t\to\infty}\Omega(t) = \Omega_0$, the explicitly constructed solution to the unsteady problem converges to the solution of the steady problem ($\Omega = \Omega_0$). In the second problem, the cylinder (sphere) is taken to move rectilinearly with velocity $v_0(t)$. An explicit solution is constructed with $v_0(0) = 0$, but it is shown that a limiting solution does not exist for $\lim_{t\to\infty} v_0(t) = v_0$. Since in this case no steady-state solution exists (in the necessary sense), the two problems illustrate a theorem of the author stating that, for the limit of the solutions of the unsteady problem to exist, the corresponding steady-state problem must have a solution. J. V. Wehausen, USA

3467. Gurevich, M. I., The impact of a plate with discontinuous jet flow (in Russian), *Prikl. Mat. Mekh.* **16**, 1, 116–118, Jan./Feb. 1952.

The author considers the following problems in the two-dimensional flow of a perfect incompressible fluid: Let AB be a fixed arc acting as an obstruction in a steady flow with free streamlines leaving the arc at either end. At time $t = 0$ the arc is suddenly given a velocity v_n, a known function along the arc. Find the impulsive force on the arc. This problem is treated rather briefly with certain linearizing assumptions. Detailed computations are given in the case that AB is a straight segment and the impulsive force compared with the case when the segment rests initially on an undisturbed water surface.

J. V. Wehausen, USA

3468. Pillow, A. F., The free convection cell in two dimensions, *Aero. Res. Lab., Melbourne, Rep.* A.79, 31 pp., May 1952.

Author investigates analytically the free convection cell in two dimensions by considering laminar flow. Earlier work is extended by considering nonlinear terms. In interior of cell, conduction and viscosity are neglected, and temperature and vorticity are found to be constant. Near the edge of the cell, the flow is considered as boundary layer and is solved by Rayleigh's method. End results for Nusselt number have same form as experimental results in terms of Grashoff number; however, the constant of proportionality is markedly higher.

M. W. Rubesin, USA

Compressible Flow, Gas Dynamics

(See also Revs. 3455, 3498, 3499, 3520, 3541, 3548, 3553, 3559, 3563, 3568)

3469. C. Truesdell, A new definition of a fluid, *Proc. seventh int. Congr. appl. Mech.* **2**, part II, 351–364, 1948.

While most recent modifications of the Navier-Stokes equations so as to take account of phenomena in moderately rarefied gases are derived from the kinetic theory, author here formulates a new definition of a fluid, as a particular type of continuum, whence follow more general expressions for the stresses than any hitherto suggested. A complete account is in preparation. The present paper illustrates the simplicity and cogency of the underlying method. It is concerned with a continuous medium such that each particle constitutes a thermodynamic system which possesses internal energy (per unit mass) $\epsilon = \epsilon(\sigma, \eta)$, where σ is the

specific volume and η is the entropy per unit mass. Pressure and temperature are then defined by $p = -\partial\epsilon/\partial\sigma$, $\theta = \partial\epsilon/\partial\eta$.

On the other hand, if T is the stress tensor, the mean pressure is defined independently of p by $p_m = -T_1/3$, where T_1 is the first scalar invariant of T. Introducing the tensor $w = pI + T$, where I is the idemfactor, it follows that there exists a dissipation function $\Phi = w..D$, where D is the rate-of-deformation tensor and the notation means the twice-contracted product of the tensors w and D. The dissipation function measures the rate at which mechanical work is being transformed into thermal energy. The author's definition of a Stokesian compressible fluid is then a continuous medium such that: (1) There exist material constants μ_0 (dimensions $M^{-1}L^{-1}T^{-1}$) and θ_0 called, respectively, the reference viscosity and temperature.

(2) The dissipation function is $\Phi = \Phi(\mu_0, \theta_0, \theta, p_m, D)p$, and is an analytic function of D.

(3) If $D = 0$, then $w = 0$.

The analytic character of Φ with respect to D entails, in the isotropic case, the existence of a power-series expansion in terms of the scalar invariants of D. A dimensional discussion of this power series reveals that, in addition to the usual parameters which govern dynamic similarity, there must be introduced a parameter of the form $\mu B\delta/p$, where B is a certain dimensionless third-order coefficient of viscosity, and δ is of dimensions minus one in time, say a rate of deformation, or vorticity which is characteristic of the motions being compared. Thus, in contrast with the classical theory in a general Stokesian fluid, time, frequency, expansion, or vorticity must always be taken into account in considerations of similarity.

L. M. Milne-Thomson, England

3470. Delval, J., On the dynamics of perfect fluids and Hamilton's principle (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **37**, 11, 986–990, 1951.

Basset ["A treatise on hydrodynamics," **1**, Deighton Bell, Cambridge, 1888, see §4] derived Euler's dynamical equation for ideal compressible fluids from a Hamiltonian variational principle, using the continuity equation as a side condition. The author prescribes the Eulerian coordinates $x^i = \xi^i$ of the boundary points of a given fluid mass. By adding to the action integral the quantity

$$\int_0^t \iint_\sigma \mu_i(x^i - \xi^i)d\sigma dt$$

where σ is the Lagrangian boundary surface and the components μ^i are multipliers, he thus obtains boundary conditions as well.

C. Truesdell, USA

3471. Thomson, K. D., The supersonic pressure drag of a swept wing with a cranked maximum thickness line, *Aero. Res. Counc. Lond. curr. Pap.* 61, 29 pp., 7 figs., June 1950, published 1951.

Wing considered has root section with constant rhombic profile; sweepback is assumed large enough to make (parallel) leading and trailing edges and maximum camber line "subsonic." Leading edge of the tip section is prolonged leading edge of root section; trailing edge of tip section is perpendicular to x. Maximum camber line accordingly bifurcates, one branch being parallel to x.

Method of source distribution is used to compute drag at zero incidence. Three basic triangular area distributions must be used [see Ferri, "Elem. Aerod. supers. Fl.", figs. 205, 203, 204] and the corresponding x-inductions integrated for a considerable number of configurations. Necessary formulas are developed completely and tabulated for a set of values of tan (sweepback) $(M^2 - 1)^{1/2}$. For one particular configuration with 60° sweepback, the mean drag coefficient averages about 2.8 (thickness ratio)^2 for $1.09 < M < 2$ with small deviations. It appears possible to approximate the drag coefficient by a weighted mean of the drag coefficients of root and tip section considered independently.

G. Kuerti, USA

3472. Morikawa, G. K., A non-planar boundary problem for the wave equation, *Quart. appl. Math.* **10**, 2, 129–140, July 1952.

Author considers linearized supersonic flow past a half plane (or rectangular wing of large aspect ratio) at incidence α, which is attached to a circular body at zero incidence, infinite (or sufficiently long) in both directions. This problem is rightly regarded as fundamental for the theory of wing-body interference. The Laplace transformation is applied to the coordinate in the free-stream direction, and the transformed problem is solved by a Green's function method. It is found that the transformation back to the physical plane presents considerable analytical difficulties. For that reason, author studies first two simplified problems: (1) The body is replaced by a flat plate approximately in the plane of the wing but at zero incidence; (2) the body has infinite radius, i.e., it is an infinite plate normal to the wing. An approximate Green's function is then suggested for the more general case, and this is transformed back to the physical plane, again approximately. It appears that the approximations are satisfactory, at least near the wing-body junction at the leading edge and far downstream. Quantitative results are shown on graphs. To appreciate the value of the author's contribution, it should be remembered that exact solutions for such problems are exceedingly difficult to obtain.

It is not clear to the reviewer why the complementary case—wing at zero incidence, body at incidence α—is dismissed in a few sentences. However, it may be that this case is considered more fully in two longer papers to which the author refers (a thesis and a California Institute of Technology report, both unpublished).

A. Robinson, Canada

3473. Morkovin, M. V., Migotsky, E., Bailey, H. E., and Phinney, R. E., Experiments on interaction of shock waves and cylindrical bodies at supersonic speeds, *J. aero. Sci.* **19**, 4, 237–248, Apr. 1952.

Paper concerns an experimental investigation studying the shock-wave reflections from a cylinder that is aligned with a steady air stream flowing at Mach number 1.90. (Experiments were conducted in the University of Michigan supersonic tunnel.) Authors explain the physical differences between the two- and three-dimensional problems of shock-wave formation by noting that in the three-dimensional case (a) the flow field downstream of the reflected wave is not uniform and usually involves a cross flow after reflection, and (b) the pressure gradient controlling the boundary layer may have an appreciable component normal to the preshock streamlines. The principal task of the experimenters was to investigate the regions of anomalous reflections and to obtain the main characteristics of the boundary layer and post-reflection cross flow due to changes in the boundary layer, shock strength, and other effects. The case of plane-shock cylinder configuration was chosen because of technically important applications (wing-body interaction). Several methods such as schlieren photography, shadowgraphs, the so-called vapor techniques, and others were used to obtain pictures of the shock-reflection pattern. Some of the excellent pictures obtained with these techniques are reproduced in the paper. They represent an important contribution to the understanding of interaction of shock waves and cylindrical bodies. The pressure distribution along the cylindrical body was measured with small orifices in order to study the influence of boundary-layer thickness on weak and strong

shock patterns. Observations show that the shock reflections on the lee side are fundamentally different from the incident side, because on the incident side the oncoming shocks induce velocities directed into the surface of the body, while on the lee side the induced velocities have a component directed away from the body. The authors give a careful analysis of their results and a comparison with theoretical conclusions and with the results of two-dimensional experiments on laminar and turbulent boundary layers. Applications of the experimental results to engineering uses, especially wind-tunnel testing, are discussed.

K. Pohlhausen, USA

3474. Ting, L., and Ludloff, H. F., Aerodynamics of blasts, *J. aero. Sci.* **19,** 5, 317–328, May 1952.

Problem of a straight shock advancing over a thin obstacle initially immersed in stationary air is investigated by the usual small perturbation method without assuming that the flow after the shock is irrotational or conical, as in previous papers. An analytical solution is obtained by the singularities method after transforming the problem by a Lorentz transformation in order to simplify the boundary conditions. The strengths of the singularities are found by inspection over part of the domain and are determined by a boundary-value problem over the remaining portion. An example is computed for a shock passing over a thin wedge.

Hideo Yoshihara, USA

3475. Brinkley, S. R., Jr., and Kirkwood, J. G., On the condition of stability of the plane detonation wave, Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 586–590, 1949. $13.50.

From the equations of momentum, continuity, energy, and state, together with the Rankine-Hugoniot shock relations, authors deduce four equations for four partial derivatives of velocity and pressure at the wave front. From these equations, a total differential equation for peak pressure is formulated in terms of the energy function, particle velocity, and the speed of sound. By assuming that the reaction rate is infinite and that the work done against pressure is initially monotone decreasing with time, it is shown that the well-known Chapman-Jouquet condition corresponds to the stable steady condition and that other conditions will either make the peak pressure decrease or increase with time until the stable steady state is reached.

Y. H. Kuo, USA

3476. Corrsin, S., and Uberoi, M. S., Spectra and diffusion in a round turbulent jet, *NACA Rep.* 1040, 21 pp., 1951.

Supersedes paper reviewed in AMR **4,** Rev. 351.

3477. Van Dyke, M. D., High-speed subsonic characteristics of 16 NACA 6-series airfoil sections, *NACA TN* 2670, 65 pp., Mar. 1952.

Section drag, lift, and pitching moment coefficients are presented of NACA 63-, 64-, and 66-series airfoil sections having thickness ratios of 6, 8, 10, and 12%, measured in a wind tunnel at Mach numbers up to 0.9.

Airfoil sections with minimum pressure near 40% chord exhibit the best over-all aerodynamic characteristics.

From the author's summary by A. Petroff, USA

3478. Laitone, E. V., A study of transonic gas dynamics by the hydraulic analogy, *J. aero. Sci.* **19,** 4, 265–272, Apr. 1952.

The theory governing the propagation of surface water waves is analyzed to show that an analogy with the two-dimensional flow of a perfect gas exists only if the water depth is approximately 1/4 in., the model is fairly large, and the shock waves or hydraulic jumps present are of the weak type having a negligible increase in entropy.

Photographs of the water surface waves corresponding to shock waves in front of simple wedges and circular cylinders are presented to illustrate these restrictions. It is pointed out that the surface-wave group velocity, which could be considerably less than the so-called wave velocity, provided the only correct analogy to the speed of sound in two-dimensional gas flow over a closed body.

Motion pictures were taken in order to study the effect of constant acceleration on bow shock waves. It was found that at high rates of acceleration the location of a detached shock wave was dependent mainly on a nondimensional acceleration parameter and was practically independent of the instantaneous Mach number.

From author's summary by S. B. Berndt, Sweden

3479. Riabouchinsky, D., On the singularities of the transonic regime and the problem of the airfoil of minimum resistance at supersonic velocities (in French), *C. R. Acad. Sci. Paris* **233,** 22, 1330–1333, Nov. 1951.

Author writes the linearized equations of small perturbations of a stream, for both subsonic and supersonic cases. After choosing solutions of a special form, he reaches the incredible conclusions (1) that for subsonic flow the pressure at the boundary of a cylinder is proportional to $|dy/dx|$, where $y(x)$ is the cylinder contour, and (2) that for supersonic flow it is proportional to dy/dx as in Ackeret's well-known approximation, but with an arbitrary coefficient of proportionality. By proper choice of this constant, he believes that he can avoid the singularity at sonic stream speed.

W. R. Sears, USA

3480. Spreiter, J. R., On the application of transonic similarity rules, *NACA TN* 2726, 45 pp., June 1952.

The transonic aerodynamic characteristics of wings of finite span are discussed from the point of view of a unified small perturbation theory for subsonic, transonic, and supersonic flows about thin wings. This approach avoids certain ambiguities which appear if one studies transonic flows by means of equations derived under the more restrictive assumption that the local velocities are everywhere close to sonic velocity. The relation between the two methods of analysis of transonic flow is examined, the similarity rules and known solutions of transonic flow theory are reviewed, and the asymptotic behavior of the lift, drag, and pitching-moment characteristics of wings of large and small aspect ratio is discussed. It is shown that certain methods of data presentation are advantageous for the effective display of these characteristics.

From author's summary by S. B. Berndt, Sweden

3481. Miles, J. W., Slender body theory for supersonic steady flow, *J. aero. Sci.* **19,** 4, 280–281, Apr. 1952.

Statement of results of analysis (including limits on parameters permitting linearization and estimates of magnitude of neglected terms) which completes the generalization of Ward's method [AMR **3,** Rev. 529], partly published by author [AMR **4,** Rev. 3003].

M. V. Morkovin, USA

3482. Martin, J. C., A vector study of linearized supersonic flow. Applications to nonplanar problems, *NACA TN* 2641, 81 pp., June 1952.

A vector study of the partial differential equation of steady linearized supersonic flow is presented. General expressions, which relate the velocity potential in the stream to the conditions on the disturbing surfaces, are derived. In connection with these

general expressions the concept of the finite part of an integral is discussed.

A discussion of problems dealing with planar bodies is given, and the conditions for the solution to be unique are investigated.

Problems concerning nonplanar systems are investigated, and methods are derived for the solution of some simple nonplanar bodies. The surface-pressure distribution and the damping in roll are found for rolling tails consisting of four, six, and eight rectangular fins for the Mach number range where the region of interference between adjacent fins does not affect the fin tips.

Chieh-Chien Chang, England

3483. Manwell, A. R., A note on the hodograph transformation, *Quart. appl. Math.* **10,** 2, 177–184, July 1952.

Author extends Friedrichs' results [AMR **3,** Rev. 753] slightly to show that, if the boundary streamline in the hodograph plane of a solution for the plane compressible flow can be mapped into the physical plane, then so can the whole field. The Jacobian transformation cannot vanish in the interior since it would then have to change sign along at least one of the characteristics through the zero, and this leads to a contradiction with its boundary behavior. The stability of solutions is discussed briefly. There are some misprints. A. F. Pillow, Australia

3484. Zienkiwicz, H. K., An investigation of boundary layer effects on two dimensional supersonic aerofoils, *Coll. Aero. Cranfield Rep.* 49, 82 pp., 28 figs., Dec. 1951.

Various viscous phenomena associated with flow over supersonic airfoils are studied in order to develop a method for estimating the viscous effects on their aerodynamic characteristics.

In regions where classical boundary-layer theory is valid, the concept of displacement thickness and equivalent wing profile is applied to determine the variations in the aerodynamic characteristics of the airfoils due to altered local pressure distribution. These variations are approximately proportional to Re, where Re denotes the Reynolds number and where $n = 1/2$ for laminar and $n = 1/5$ for turbulent boundary layers.

A drag-entropy relation and a lift relation are derived from the momentum theorem and are used to demonstrate the over-all effects of the boundary-layer shock-wave interaction. Local flow conditions affected by this interaction are examined in detail, and it is believed to cause flow separation. On the basis of available experimental data, an empirical correction is suggested for the effects of flow separation at the trailing edge, and it is found that, with the laminar boundary layer, these effects are of major importance. It is expected that their influence will diminish at high Reynolds numbers and will be negligible with turbulent boundary layers.

The suggested method of estimating the boundary-layer effects is applied to the particular case of a 10% circular-arc profile at $M = 2.13$ and $Re = 0.64 \times 10^6$. Comparison with experiment is not conclusive because of the lack of reliable data.

A new integral relation for laminar boundary layers in simple-wave flow and zero heat transfer is developed and is found to give good agreement with the approximate method of Howarth [AMR 2, Rev. 357]. A brief discussion is also given of the relative merits of the circular-arc and double-wedge profiles.

From author's summary by Simon Ostrach, USA

3485. Shen, S. F., On the boundary-layer equations in hypersonic flow, *J. aero. Sci.* **19,** 7, 500–501, July 1952.

Readers' Forum note discusses connection between two unpublished treatments of viscous hypersonic flow past a wedge. Author applied boundary-layer equations to entire field between shock and wedge near nose [Sc.D. Thesis, M.I.T., 1949]. Lees and Probstein matched boundary-layer solution to outer inviscid Prandtl-Meyer flow and found asymptotic solution far from nose [Ann. Meeting, Amer. phy. Soc., New York, 1952].

M. D. Van Dyke, USA

3486. Acum, W. E. A., A brief survey of some methods and information concerning the aerodynamic derivatives of wings in unsteady motion at transonic and supersonic speeds, *Aero. Res. Counc. Lond. curr. Pap.* 85, 14 pp., 1952.

3487. Moskowitz, B., Approximate theory for calculation of lift of bodies, afterbodies, and combinations of bodies, *NACA TN* 2669, 39 pp., Apr. 1952.

Slender-body theory is adapted to calculate lift forces on combinations of bodies, such as fuselages with externally mounted propulsive units, and to correct the slender-body result that a cylindrical afterbody experiences no lift force.

G. N. Ward, England

3488. Lessen, M., On the stability of plane parallel laminar flows to two- and three-dimensional disturbances, *J. aero. Sci.* **19,** 6, 431–432, June 1952.

In reviewer's opinion, this is an excessively mathematical analysis with no novel conclusions. Chas. Newman, USA

3489. Hasimoto, H., On the asymptotic behaviour of three-dimensional compressible fluid flow at a great distance from a body. I. The force and moment on a solid body in a stream of compressible fluid, *J. phys. Soc. Japan* **6,** 5, 383–387, Sept./Oct. 1951.

Author expands the velocity potential function for steady incompressible flow into a series

$$\Phi = U[r\cos\theta + A_1 r^{-1} + A_2 r^{-2} + \sum_{3}^{\infty} A_n(\theta, \omega) r^{-n}]$$

where r, θ, ω are spherical polar coordinates, $(U, 0, 0)$ is the Cartesian velocity at infinity, corresponding to Mach number M

$$A_1 = a_0(1 - M^2\sin^2\theta)^{-1/2}$$

$$A_2 = (1 - M^2\sin^2\theta)^{-1.5} \times [a_{1,0}\cos\theta + \sin\theta(a_{1,1}\cos\omega + a_{1,-1}\sin\omega)]$$

$a_0, \ldots, a_{1,-1}$ are constants, and the exact forms of A_n are not required here. By considering the balance of momentum and angular momentum of the fluid in a large sphere $r = \text{const}$ and passing to the limit $r \to \infty$, he obtains for the force on the body the Cartesian components $-\rho_\infty Q_\infty U, 0, 0$, and for the moment 0

$$4\pi a_{1,-1}\rho_\infty U^2/(1 - M^2),\ -4\pi a_{11}\rho_\infty U^2/(1 - M^2)$$

Here ρ_∞ is the density at infinity, and $\rho_\infty Q_\infty$ is the total outward rate of mass flow at infinity, originating from sources in the body.

Courtesy of Mathematical Reviews J. H. Giese, USA

3490. Reissner, H. J., Meyerhoff, L., and Bloom, M., Two-dimensional steady nonviscous and viscous compressible flow through a system of equidistant blades, *NACA TN* 2718, 48 pp., June 1952.

By assuming a system of infinitesimally spaced blades, two-dimensional steady nonviscous compressible flow may be determined as a function of one space variable, freely prescribing the distribution of enthalpy as a basic variable. Inverse problem of calculating the variables for a prescribed blade shape is not investigated. Transition to finite spacing is made by suitable expansions in power series of a transverse space variable. Two types

of finitely spaced airfoils are readily derived, of zero or finite thickness. Numerical application to the former is made. A simple extension to viscous flow is made, assuming average transverse distribution of the variables. G. Moretti, Argentina

3491. Griffith, W., Shock-tube studies of transonic flow over wedge profiles, *J. aero. Sci.* **19, 4, 249–257, 264, Apr. 1952.**

Paper summarizes experimental results obtained in Princeton shock tube for transonic flow past wedge profiles. Several different types of experiments are included: The location and shape of detached bow waves on wedges ranging from 10° to 180° total angle; the location of the sonic line; the pressure distribution and drag coefficient of the wedge; and comparison of shock-tube measured-drag coefficient on 15° wedge with wind-tunnel measurement and theory over range of Mach numbers from about 0.8 to 1.4. Shock-tube measured-drag coefficients agree well with Cole's calculation for $M \leqq 1$, for Cole and Guderley's calculation at $M = 1$ for both slope and ordinate, with Vincenti's calculation for $M > 1$; they also agree fairly well with Liepmann and Bryson's transonic tunnel measurements below $M = 0.85$, and quite well for their measurements above $M = 1.2$.

Paper includes brief discussion of interferometric measurement technique. In reviewer's opinion, more complete description of experiments is needed to show that flow has achieved equilibrium at measurements very close to $M = 1$. Reviewer believes this to be most complete set of experimental determinations of two-dimensional flow characteristics over wedges.

H. G. Stever, USA

3492. Parks, E. K., Supersonic flow in a shock tube of divergent cross-section, *Inst. Aerophys. Univ. Toronto UTIA Rep.* **18, 31 pp., 51 figs., May 1952.**

Author considers supersonic flow in a shock tube which incorporates a smooth expansion behind a sharp corner. A simplified "pseudo-stationary" (or conical unsteady) theory is developed for the diffraction of a plane shock wave passing over an outside corner. Both subsonic and supersonic flow behind the shock are treated. The results of the latter case are applied to the shock tube, and the wall pressures and wave velocities are calculated using a one-dimensional analysis. Experimental verification is obtained, and it is pointed out that the divergent shock tube, because of the very short duration, can withstand temperatures far in excess of those that could cause structural failure in steady-flow wind tunnels. Hence, condensation and liquefaction are avoided at high Mach numbers. Alvin H. Sacks, USA

3493. Hall, N. A., The action of friction in nonsteady flow of fluids, Proc. Midwest. Conf. Fluid Dynamics, 1st Conf., May 1950; J. W. Edwards, Ann Arbor, Mich., 340–353, 1951. $10.

Author sets up characteristic equations for unsteady one-dimensional frictional fluid flow, and discusses various solutions. Contains a useful bibliography. There are some typographical errors. C. E. Pearson, USA

3494. Eggers, A. J., Jr., and Syvertson, C. A., Inviscid flow about airfoils at high supersonic speeds, *NACA TN* **2646, 65 pp., Mar. 1952.**

It is shown that, within assumption of ideal gas flow, shock-expansion method for predicting pressure distributions may be used with good accuracy at arbitrarily high Mach numbers. Approximate application of shock-expansion method is investigated and found to give pressure distributions in error by less than 10% at Mach numbers above 3, and flow-deflection angles up to 25°. Tables are presented to facilitate its use. Variation of the ratio of specific heats can be incorporated in shock-expansion method with good accuracy for the specific heat range 1.4 to 1.3. Busemann method for infinite Mach number is better than shock-expansion theory for extremely high Mach numbers.

Keith C. Harder, USA

3495. Harder, K. C., Transonic similarity rules for lifting wings, *NACA TN* **2724, 26 pp., June 1952.**

Similarity rules for the transonic flow about lifting wings are derived by considering the change in the flow field due to angle of attack as a small perturbation to the nonlifting flow field. This approach has the advantage that the effects of angle of attack and airfoil geometry are partially separated.

It is found that the lift coefficient is proportional to the angle of attack, as in other speed ranges. Other results are that the drag due to lift is proportional to the square of the lift coefficient as in other speed ranges, and that the expression for the ratio of lift to drag is very similar to that obtained at supersonic speeds. It is found that the maximum value of the lift-to-drag ratio is approximately inversely proportional to the first power of the wing-thickness ratio for cases in which the skin-friction drag is negligible compared with the pressure drag. For cases where the angle of attack is large compared with the thickness ratio, the lift coefficient is proportional to the angle of attack to the two-thirds power.

Since the effects of angle of attack and wing geometry are partially separated, the present form of the similarity rules is useful for correlation work. Experimental data indicate that such a correlation will be possible for lift-coefficient range extending beyond the lift coefficient for maximum lift-to-drag ratio. Thus, many interesting results may be presented in terms of the similarity rules for low lift coefficients.

It is shown that the transonic similarity rules are valid at subsonic speeds but are more complicated in that range than the well-known rules of Prandtl-Glauert.

From author's summary by H. R. Lawrence, USA

3496. Flax, A. H., General reverse flow and variational theorems in lifting-surface theory, *J. aero. Sci.* **19, 6, 361–374, June 1952.**

Certain reciprocal theorems of elasticity, electrostatics, and dynamics can be derived from the self-adjoint properties of the governing differential equations or their associated integral equations. In aerodynamics and wing theory, equivalent results can be obtained provided the induced fields of the wing in forward and reversed flight directions are related. The present paper deals specifically with lifting-surface theory for wings in uniform motions, and derives general theorems through a study of the self-adjoint integral equations for incompressible and compressible fluid flow. Munk's two-dimensional airfoil theorems are generalized to include formulas for total lift, pitching moment, and rolling moment on a wing with specified boundary conditions. Reverse-flow relationships are shown to aid in the formulation of a variational principle for lifting surfaces in subsonic flow. In combination with the form of the Rayleigh-Ritz method, the variational approach is shown to lead to suitable methods for approximate solutions of lifting-surface problems and to avoid the intuitive steps common to several existing lifting-line and low-aspect-ratio theories. Max A. Heaslet, USA

3497. Chapman, D. R., An analysis of base pressure at supersonic velocities and comparison with experiment, *NACA Rep.* **1051, 23 pp., 1951.**

Supersedes paper reviewed in AMR **4**, Rev. 2151.

Turbulence, Boundary Layer, etc.

(See also Revs. 3476, 3484, 3593)

3498. Mair, W. A., Experiments on separation of boundary layers on probes in front of blunt-nosed bodies in a supersonic air stream, *Phil. Mag.* (7) **43**, 342, 695–716, July 1952.

Interesting results, based mainly on a series of schlieren photographs of experiments on flow at a Mach number of 1.96 over a hemispherical-nosed and a flat-nosed body, each with a slender sharp-edged probe attached in front, are presented and discussed. The flow characteristics depend especially on the parameter K (= length of probe/diam of body of revolution). Results for the flat-nosed body indicated, for example, that for very small K (<0.44), the probe was entirely behind the bow shock wave on the body; for $K = 1.3$ to 1.5, the flow separated at the point of the probe, while for $K = 1.5$ to 2.1, separation occurred at the shoulder of the probe. In both of the latter cases, there was a conical dead-air region behind the separation point. For $K = 0.7$ to 1.3, an oscillating flow of high frequency (6000 cps) was observed. The detailed discussion of this flow involves interaction among the boundary layers and the shock waves (normal and oblique) on the probe and on the body. Results for flow over the hemispherical-nosed body were qualitatively similar to the above, except that the oscillating flow was not observed.

Pressure measurements over the round-nosed body indicated that the addition of the probe ($K = 1.44$) *halved* the drag of the hemispherical nose.

To observe corresponding two-dimensional flow, a thin plate was clamped between two thicker flat plates. Results qualitatively similar to the above axially symmetric flows were obtained.

The types of flow investigated in this paper are of especial interest in connection with the interaction of the boundary layer and a shock wave. Thus, in supersonic flow over a blunt-nosed body with a flat plate attached in front, the rise of pressure at the bow wave in front of the body causes separation of the boundary layer on the plate. This in turn distorts the streamlines outside of the boundary layer, and produces an adverse pressure gradient on the plate, which causes the separation point to move upstream. M. Morduchow, USA

3499. Libby, P. A., Morduchow, M., and Bloom, M., Critical study of integral methods in compressible laminar boundary layers, *NACA TN* 2655, 40 pp., Mar. 1952.

An examination is made of integral methods applied to compressible laminar boundary layers. One-parameter von Kármán-Pohlhausen method with four-, five-, and six-degree polynomial velocity distributions, and two-parameter method with four- and five-degree polynomial velocity distributions are compared with exact solution for insulated flat plate. Quantities compared are skin-friction coefficient, velocity distribution (including second derivatives), and critical Reynolds numbers. Authors find sixth-degree polynomial velocity distribution in von Kármán-Pohlhausen method compares best with exact results. Reviewer considers it is unfortunate authors did not consider accuracy of polynomials of higher order than six to show that added complications are unwarranted. M. W. Rubesin, USA

3500. Schröder, K., Application of the difference calculus to the analysis of the laminar boundary layer (in German), *Math. Nachr.* **4**, 439–467, 1951.

The laminar boundary-layer equation is solved by a combined iteration and finite difference method. The convergence of the finite difference part is referred to known theorems. The proof of convergence for the iteration process is carried out under certain conditions which can be checked in a practical calculation. Short cuts for practical calculation are given; several examples are worked out. In the case of the Schubauer ellipse, the point of separation is correctly predicted by an extrapolation of the skin friction. C. C. Lin, USA

3501. Sen, N. R., On Heisenberg's spectrum of turbulence, *Bull. Calcutta math. Soc.* **43**, 1, 1–7, Mar. 1951.

Author studies the equation of spectrum of turbulence with Heisenberg's form of the transfer function. Self-preserving solutions are discussed for large and small Reynolds numbers, giving essentially results known before. A partial differential equation using Chandrasekhar's variables is derived. This is again used to derive the same results. C. C. Lin, USA

3502. Reichardt, H., Laws of free turbulence, 2nd enlarged ed. (in German), Dusseldorf, Deut. Ing. Verlag, *VDI-Forschungsheft* 414, 30 pp., 1951. DM 12.50.

This edition differs from the 1942 edition only in being slightly altered and extended. A chapter is added on the velocity distribution in the direction of main flow (x-), and the theory is extended to cover the spread of heat and mass.

In their investigations of turbulence transfer processes, Boussinesq, Prandtl, Taylor, von Kármán, et al., followed a deductive method: A hypothesis is made concerning turbulence shear stress, from which, with the aid of the equations of motion and continuity and assumed similarity conditions, velocity distributions are deduced. Reichardt's main objection to this method is that relatively easily measurable quantities, such as mean velocity distribution, are derived on the basis of more or less questionable hypotheses, and that comparison with experimental data, because of their usual scatter, makes a decision in favor of a hypothesis difficult.

Reichardt follows an inductive method, deducing the theory from experimental data about directly measurable quantities; he then calculates the not easily measurable quantities, such as lateral mean velocity, total momentum transfer, and apparent turbulence shear stress, from the equation of motion and continuity. He considers the following cases: plane half jet, plane and round free jet, plane wake flow of a cylinder and of a grid.

Two aspects may be distinguished in Reichardt's work: (a) An analysis of experimental data according to above inductive method, resulting in derived distributions of lateral mean velocity, total momentum transfer, and apparent turbulent shear stress; (b) the introduction of a postulate as to total momentum transfer whereby the equation of motion can be transformed into an equation similar to that of unsteady heat conduction. The solution is the Gaussian error function. Obviously, the long-since recognized fact that velocity distributions in free turbulence can be closely approximated by Gaussian error functions has led Reichardt to above transformation of the equation of motion.

All cases of free turbulence considered are treated in a similar fashion. Therefore it may suffice to consider only, e.g., the case of a plane free jet. Since in the final application of his analysis Reichardt neglects viscosity effects and assumes a constant static pressure across the mixing zone, the starting point here will be the simplified equation of motion together with the equation of continuity $\partial\bar{u}^2/\partial x + \partial\overline{uv}/\partial y = 0$ . . . [1]; $\partial u/\partial x + \partial v/\partial y = 0$ . . . [2], where $u = \bar{u} + u'$, $v = \bar{v} + v'$, $\bar{u}^2 = \bar{u}^2 + \bar{u}'^2$ and $\overline{uv} = \bar{u}\bar{v} + \overline{u'v'}$ (u velocity component in main flow direction x, v lateral velocity component in transverse direction y, u' and v' turbulence components).

Reichardt assumes similarity of distribution profiles of mean and turbulence quantities, both thus being functions of $\zeta = y/b$ only; b is a width parameter of the mixing zone and a function of x only.

Let the subscript m refer to the maximum value in a cross section, then the law of conservation of total momentum of the entire jet in the x-direction, together with assumed similarity conditions, leads to $(\bar{u}_m^2 + \overline{u'^2}_m)b = \text{const.}$ . . . [3], or $\bar{u}_m(b)^{1/2} \simeq \text{const.}$ . . . [3a].

From [2] one obtains $\bar{v} = \alpha/b(y\bar{u} - \frac{1}{2}\int_0^y \bar{u}dy)$ . . . [4], where $\alpha = db/dx$. Furthermore, from [1] $\overline{uv} = \alpha y\bar{u}^2/b$ . . . [5], so that

$$\overline{u'v'} = \overline{uv} - \bar{u}\bar{v} = \alpha y\bar{u}^2/b - \alpha(y\bar{u}^2 - \tfrac{1}{2}\bar{u}\int_0^y \bar{u}dy)/b$$
$$= \alpha\,(y\,\overline{u'^2} + \tfrac{1}{2}\bar{u}\int_0^y \bar{u}dy)/b \ldots [6]$$

A similar analysis is given for determining $\overline{Tv}$, $\overline{T'v'}$ from mean temperature T and velocity distributions.

Above relations have been applied to mean total head measurements in a plane jet by Förthmann [*Ing.-Arch.* **5**, 42–54, 1934] and to own mean temperature measurements. Reichardt shows that $\varphi^2 = \bar{u}^2/\bar{u}^2_m$ is very closely approximated by $\exp(-\zeta^2)$, except near the outer boundaries. In calculating $\bar{v}$, $\overline{uv}$ and $\overline{u'v'}$ according to [4], [5], and [6], Reichardt introduces approximations; he assumes $\bar{u}/\bar{u}_m \simeq (\bar{u}^2/\bar{u}_m^2)^{1/2} = \varphi = \exp(-\frac{1}{2}\zeta^2)$ and neglects in [6] the effect of $\overline{yu'^2}$.

In order to transform the equation [1] into an equation for unsteady heat conduction, Reichardt postulates $\overline{uv} = -\Lambda\partial\bar{u}^2/\partial y$ . . . [7], so that [1] becomes $\partial\bar{u}^2/\partial x = \Lambda\partial^2\bar{u}^2/\partial y^2$ . . . [8].

Λ is a "transfer quantity" with the dimension of a length. [8] has the solution $\exp[-\zeta^2)$ if Λ is taken equal to $\alpha b/2$.

Introducing a transfer coefficient A defined as $\rho\overline{u'v'} = A\partial\bar{u}/\partial y$, Reichardt admits not having succeeded in obtaining a universal shear stress law.

Reviewer's comments: Though the physical interpretation of postulate [7] sounds reasonable, yet there is something queer about it. Equations [7] and [8] considered separately do not show explicitly that they must be invariant under translation at constant velocity of the coordinate system. This has already been pointed out by Prandtl [*ZAMM* **22**, 241–243, 1942]. Then there are serious objections to the way in which the correct relations [4] and [6] have been applied to data on measured total heads $\bar{u}^2$ by neglecting turbulence effects and assuming $\bar{u}/\bar{u}_m \simeq \varphi$, because in free turbulent jet flow, relative turbulence intensities are high, particularly at some distance from the axis. Serious errors are thus introduced in the values of $\overline{u'v'}$. In fact, the values calculated from the mean velocity distribution corrected for turbulence effects are 30% and lower than the values calculated by the author over a large region of the mixing zone.

Reviewer believes that the author's omissions have led him to wrong conclusions concerning the turbulence shear stress; e.g., he comes to the conclusion that Boussinesq's assumption of a constant coefficient A does not hold, since A as calculated by Reichardt varies appreciably across the mixing zone. However, it must be pointed out that, because of above neglects, both $\overline{u'v'}$ and $\partial\bar{u}/\partial y$ have been incorrectly determined. Reviewer has shown [AMR **3**, Rev. 1756] that in a round free jet the coefficient A is practically constant for the fully turbulent core region of the jet. Also, recent investigations by Townsend [AMR **3**, Rev. 1349; **1**, Rev. 911] and Batchelor [AMR **4**, Rev. 350] have shown that the Gaussian solution seems to be fundamentally correct for the mean motion in the central part of the wake flow behind a cylinder, because there are strong arguments for a constant value of A. Toward the boundaries, an intermittency factor has to be introduced. J. O. Hinze, Holland

3503. Rotta, J., Statistical theory of nonhomogeneous turbulence. II (in German), *Z. Phys.* **131**, 1, 51–77, 1951.

The author applies this theory of part I [AMR **5**, Rev. 829] to the case of two-dimensional channel flow, after introducing certain assumptions. The distributions of mean velocity and turbulence level are found to be in reasonable agreement with experiments. C. C. Lin, USA

3504. Rebuffet, P., and Poisson-Quinton, Ph., Investigations of the boundary-layer control on a full scale swept wing with air bled off from the turbojet, *NACA TM* 1331, 43 pp., Apr. 1952.

See AMR **4**, Rev. 826.

3505. Michel, R., Contribution to the study of the turbulent boundary layer with pressure gradient (in French), *Inst. aéro. Saint-Cyr, Publ. sci. tech. Min. Air, Paris* no. 252, 128 pp., 23 figs., 1951.

A superficial analytical and experimental account of turbulent boundary-layer behavior without and with static pressure gradient. The measurements, total-head tube profiles only, should be of practical interest, but, in reviewer's opinion, the analysis is largely of historical interest, including the paradox of constant pressure shear distributions which do not have flat maxima at the wall.
S. Corrsin, USA

3506. Fallis, W. B., Heat transfer in the transitional and turbulent boundary layers of a flat plate at supersonic speeds, *Inst. Aerophys., Univ. Toronto Rep.* no. 19, 38 pp., 30 figs., May 1952.

Report reviews briefly the results of analyses relating to the specification of heat transfer and thermal recovery factors for constant property, dissipative flows over flat plates for laminar and turbulent boundary layers. Experimental data are presented comprising local heat-transfer coefficients and local thermal recovery factors for flat plates for a range of variables $10^5 < Re < 6 \times 10^5$ and $M = 2.48$. These data are obtained in a 16 in. × 16 in. blow-down-type tunnel with an operating time of approximately 25 seconds. The heat-transfer coefficients are obtained by the transient method ["Determination of unit conductance for heat and mass transfer by the transient method." A. L. London, H. B. Nottage, and L. M. K. Boelter, *Indust. Engng. Chem.* **33**, 467–473, Apr. 1941] applied to small copper slugs inset into, but insulated from a copper plate. The thermal recovery factors are obtained from adiabatic wall-temperature measurements with similar copper slugs inset into a (bakelite) nonconducting plate. Because of the short time operation of the tunnel, equilibrium adiabatic wall temperatures are obtained only by extrapolation of the experimental measurements. Since this result is of paramount importance in the determination of the recovery factors and, thence, the heat-transfer coefficients, this procedure appears questionable to reviewer.

Experimental results are compared with existing theoretical results for the turbulent boundary layer and with the experimental results obtained by Eber [AMR **5**, Rev. 1812]. Author's data agree very well with those of Eber. Comparison with theoretical turbulent boundary-layer results is weakened by the fact that only two points are in this region, the remainder being translational data; moreover, those two points are 15–30% higher than the heat-transfer coefficients for turbulent boundary-layer flow as predicted by von Kármán or Colburn for flat plates.

A spot check for the local heat-transfer coefficient on a right circular cone at one Reynolds and at one Mach number yields a check on the Eber data for similar conditions.
Robert M. Drake, Jr., USA

3507. Bass, J., Local structure of space-time correlations in a turbulent fluid (in French), *C. R. Acad. Sci. Paris* **234**, 10, 1033–1034, Mar. 1952.

Author establishes that stationary homogeneous turbulence [see Bass, J., AMR **5**, Rev. 2449] cannot exist, except perhaps when viscosity is zero. G. K. Batchelor, England

3508. Maydew, R. C., and Pappas, C. C., Experimental investigation of the local and average skin friction in the laminar boundary layer on a flat plate at a Mach number of 2.4, *NACA TN* 2740, 22 pp., July 1952.

Average and local skin-friction coefficients for laminar flow have been determined experimentally on a flat plate at a Mach number of 2.4 for a Reynolds number range of 0.72×10^6 to 2.8×10^6, and compared with the laminar boundary-layer theory of Chapman and Rubesin [see AMR **3**, Rev. 2732].

The average skin-friction coefficients were calculated by the momentum-loss method from impact-pressure surveys of the boundary layer. These coefficients were plotted as a function of Reynolds number based upon distance from the plate leading edge and were 37 to 94% higher than values predicted by theory. This discrepancy is attributed to a momentum loss of unknown origin near the plate leading edge.

Local skin-friction coefficients were determined by evaluating the shear by two methods. In the first method, the shear at the wall was calculated from the measured boundary-layer Mach number gradient at the wall and the measured wall temperature. The mean value of these coefficients was well represented by the theory when the correlation was based on momentum-thickness Reynolds number, although the data showed ±20% scatter. In the second method, the shear in the boundary layer away from the wall was calculated from the measured Mach number gradient and the theoretical boundary-layer temperature distribution. These shear coefficients showed excellent agreement with the skin-friction coefficient predicted by the theory of Chapman and Rubesin when correlation was based on momentum-thickness Reynolds number. From authors' summary

Aerodynamics of Flight; Wind Forces

(See also Revs. 3471, 3472, 3487, 3504, 3546, 3579)

3509. Bird, J. D., Fisher, L. R., and Hubbard, S. M., Some effects of frequency on the contribution of a vertical tail to the free aerodynamic damping of a model oscillating in yaw, *NACA TN* 2657, 39 pp., Apr., 1952.

Damping and directional stability were measured at $M = 0.14$ by the free oscillation method in the range 0 to 0.032 of the reduced-frequency parameter k (referred to the vertical tail semi-chord). Results are presented together with predictions of several unsteady-lift theories for values of k from 0 to 1. The agreement between theory and experiment is good for damping but less satisfactory for directional stability. The experimental results show no variation with k in the range covered.

Reviewer believes there are errors in sign on p. 8 in three equations for frequency, damping constant, and directional stability; however, the experimental results appear to be correct. He also believes that authors' inclusion of $N_{\dot{\psi}}$ term when it is later considered part of the directional stability is misleading and actually erroneous in equation (3); the results appear to be obtained by setting $N_{\dot{\psi}}$ zero and so are correct. J. M. Evans, Australia

3510. Bird, J. D., Lichtenstein, J. H., and Jaquet, B. M., Investigation of the influence of fuselage and tail surfaces on low-speed static stability and rolling characteristics of a swept-wing model, *NACA TN* 2741, 18 pp., July 1952.

Tests made in straight flow showed that the 45° sweptback wing alone has marginal longitudinal stability characteristics near maximum lift. The variation of rolling-moment coefficient with angle of yaw of the complete model is almost the same as for the wing alone.

Results of tests made in simulated rolling flight indicate that, for this model, the effects of the fuselage and tail surfaces on the rate of change of the rolling-moment, yawing-moment, and lateral-force coefficients with wing-tip helix angle are small in comparison with the effect of the angle of attack on these rotary characteristics. The vertical tail produces larger increments of the rate of change of lateral-force and yawing-moment coefficients with wing-tip helix angle than the fuselage or horizontal tail.

From authors' summary

3511. Queijo, M. J., and Wolhart, W. D., Experimental investigation of the effect of vertical-tail size and length and of fuselage shape and length on the static lateral stability characteristics of a model with 45° sweptback wing and tail surfaces, *NACA Rep.* 1049, 29 pp., 1951.

Supersedes paper reviewed in AMR **4**, Rev. 2160.

3512. Brewer, J. D., and Fisher, L. R., Effect of taper ratio on the low-speed rolling stability derivatives of swept and unswept wings of aspect ratio 2.61, *NACA TN* 2555, 17 pp., Nov. 1951.

Tests conducted under conditions simulating rolling flight showed that a decrease in ratio of tip chord to root chord of a swept wing caused a small decrease in damping-in-roll at low and moderate lift coefficients; at high lift coefficients, decrease in taper ratio caused a large reduction in damping-in-roll and, for untapered wing, greatly reduced the increase in damping which exists prior to maximum lift. Theory predicts effect of change in taper ratio more accurately than effect of sweep for derivatives of rate of change of yawing moment due to roll, with lift coefficient and damping-in-roll at zero lift. Tip suction effects, not accounted for by theory, may cause large errors in theoretical values of yawing moment and lateral force due to roll. Method for estimating correction for tip suction force is illustrated.

E. Lapin, USA

3513. McKinney, M. O., Jr., Analysis of means of improving the uncontrolled lateral motions of personal airplanes, *NACA Rep.* 1035, 9 pp., 1951.

Supersedes paper reviewed in AMR **3**, Rev. 962.

3514. Reeder, J. P., and Whitten, J. B., Some effects of varying the damping in pitch and roll on the flying qualities of a small single-rotor helicopter, *NACA TN* 2459, 23 pp., Jan. 1952.

Flight-test measurements and pilots' opinions are presented of the longitudinal flying qualities and lateral control characteristics of a small single-rotor helicopter. Longitudinal stability and control characteristics which were unsatisfactory with the device inoperative, were improved by increasing the damping of the helicopter and were judged as satisfactory when the damping was approximately doubled by the device. The tests tended to confirm the proposed requirements of *NACA TN* 1983 [see AMR **3**, Rev. 2454] that, for satisfactory stability, the curve for normal acceleration in a pull-and-hold maneuver should become concave downward within 2 seconds of the start of the maneuver. The largest amount of damping tested resulted in correspondingly reduced rates of roll. Although noticeably low, these rates seemed adequate to the pilots for normal flying.

From authors' summary

3515. Fisher, W. A. P., Fatigue of helicopters, *Aircr. Engng.* **24**, 278, pp. 106, 117, Apr. 1952.

A reply to Mr. J. Shapiro's article, "Airworthiness requirements and the fatigue of helicopters" [AMR **4**, Rev. 2491].

3516. Gessow, A., and Crim, A. D., An extension of lifting rotor theory to cover operation at large angles of attack and high inflow conditions, *NACA TN* 2665, 36 pp., Apr. 1952.

Analytical expressions for blade motion, rotor thrust, and torque and profile drag of a hinged rotor are presented. These data are particularly applicable for rotors operating at tip-speed ratios exceeding 0.25 or at very high angles of attack of high-speed compound helicopters or convertible aircraft. The theory presented assumes that no limitation is placed upon the magnitude of blade-section inflow angle. Blade stall for the reversed-flow region is also accounted for in this new theoretical treatment.

R. A. Young, USA

3517. Rogers, R. A., Extension of "the dynamic effects in rotor blade bending," *J. aero. Sci.* **19,** 5, 349–350, May 1952.

Methods developed by Flax and L. Goland [AMR **5,** Rev. 2908] are extended to the case of propeller blades near resonance with the periodic aerodynamic forcing functions. Basic differential equation of blade bending is solved for boundary conditions of the propeller blade. Expression is obtained for the amplification factor by which static deflection or bending moment may be multiplied to obtain their dynamic values.

W. Z. Stepniewski, USA

3518. Chawla, J. P., Effect of flapping hinge offset on rotor blade stall, *J. aero. Sci.* **19,** 7, 498–499, July 1952.

By using conventional helicopter analysis and neglecting effect of reverse flow, author shows that, with normal values ($\gamma = 12$) of Lock's number, the stall conditions at the retreating blade tip are only slightly improved by a flapping-hinge offset up to 20%.

Reviewer's note: In a forthcoming paper, J. R. Meyer, Jr., and G. Falabella, Jr., show that with low values ($\gamma = 2$) of Lock's number, however, the angle of attack at the retreating blade may be substantially reduced by large flapping-hinge offsets.

H. Parkus, USA

3519. Stewart, Wm., Some recent helicopter research investigations, *J. Helicop. Assn.* **6,** 1, 3–12, Apr./May/June/July 1952.

Author advances some arguments in favor of applying second harmonic control to the rotor as a means of increasing the high speed of the helicopter. By reducing the loading on the lateral sectors of the disk and increasing it fore and aft, it is proposed to minimize the rotor-blade stall now so predominant on rotors utilizing only the first harmonic cyclic pitch control.

A brief introduction to the frequency-response theory for determining rotor-blade motions is given. It is stated that "the frequency ratio effect is not of much significance in the stability of the full-scale helicopter, but for oscillations of short period it could be important." Wind-tunnel tests conducted on a 12 ft-diam rotor tend to verify the statement of the importance of not only investigating stability by the quasistatic theory but also by the frequency-response theory for the critical conditions.

R. A. Young, USA

3520. Jones, A. L., and Alksne, Alberta, A summary of lateral stability derivatives calculated for wing plan forms in supersonic flow, *NACA Rep.* 1052, 35 pp., 1951.

Values of the lateral-stability derivatives for wings at supersonic speeds, calculated using the linearized theory for compressible flow, are presented in the form of design charts showing the variations of the derivatives with Mach number and aspect ratio for six planforms. Limitations in the applicability and availability of the lateral-stability derivatives are discussed.

From authors' summary by Seymour Lampert, USA

3521. Robinson, A., Aerofoil theory for swallow tail wings of small aspect ratio, *Coll. aero. Cranfield Rep.* 41, 1 pp., Jan. 1951.

Correction to paper reviewed in AMR **4,** Rev. 2127.

3522. Lichtenstein, J. H., Effect of high-lift devices on the low-speed static lateral and yawing stability characteristics of an untapered 45° sweptback wing, *NACA TN* 2689, 20 pp., May 1952.

Tests were made in the 6 ft × 6 ft curved-flow test section of the Langley stability tunnel and covered measurements of derivatives of yawing and rolling moments and of side force with respect to sideslip and yaw for the wing alone, wing with full span 10% chord leading-edge flap, wing with 0.4-span and 0.9-span split trailing-edge flaps of 20% chord, and wing with both leading and 0.9-span trailing-edge flaps. The setting of the leading-edge flap was 50° and that of the trailing-edge flap was 60°. The inboard 0.4-span trailing-edge flap reduced both the rolling moment due to sideslip and yawing in most cases, but the 0.9-span flap increased these derivatives. Both trailing-edge flaps increased the yawing moments due to sideslip and yaw, but the effect was much more marked with the 0.9-span flap. The leading edge flaps generally helped to extend these effects to higher lift coefficients. The effects on the side force due to sideslip or yaw were small. Author suggests that the similarity between the effects on the derivatives with sideslip and those due to yaw indicate that the effects of the flaps on stability derivatives due to yaw can be predicted from the simpler experimental study of the stability derivatives due to sideslip.

A. D. Young, England

3523. Scanlan, R. H., Pressure distribution on an airfoil in nonuniform motion, *J. aero. Sci.* **19,** 7, p. 502, July 1952.

Author shows that S. Neumark's claim [AMR **5,** Rev. 3131], of having found the "long anticipated formula" for arbitrary motion of an airfoil is not justified. Formulas given earlier by Garrick and others are more general since, in Neumark's results, the wake term still has to be evaluated.

Horst Merbt, Sweden

3524. Rosenberg, R. M., Comments on "horizontal tail loads in abrupt pull-ups from level flight," *J. aero. Sci.* **19,** 4, 282–283, Apr. 1952.

Author discusses certain theoretical mathematical questions in connection with original paper [AMR **5,** Rev. 2459]; specifically, those of uniqueness and existence of solution. Applicability of inverse method to solution of nonlinear equations is also discussed.

Gabriel Isakson, USA

3525. Rosenberg, R. M., and Stoner, G., On the flight dynamics of slender special-purpose aircraft, *J. aero. Sci.* **19,** 1, 29–38, Jan. 1952.

Dynamic equations for a slender aircraft with essentially circular symmetry are developed. Body is assumed to be without roll and with one side-bending and one vertical-bending vibratory mode; thus, six degrees of freedom are involved. Additional restrictions give differential equations which are linear with constant coefficients. All aerodynamic derivatives are computed from partial derivatives of forces known either from theory or wind-tunnel tests. Unsteady air forces were not used, thus restricting discussion to velocities well below the flutter speed. An application to a step-control surface displacement, considering only primary aerodynamic forces, is made and compared with experimental results. Extension to additional vibratory modes and use of unsteady air forces can be made, but will require greatly increased computational facilities. Perturbation methods can be applied to modify other restrictions.

E. T. Welmers, USA

3526. von Kármán, T., Jet assisted take-off, *Interavia* **7,** 7, 376–379, 1952.

The use of JATO (jet-assisted take-off rockets) enables guided missiles, ramjet fighters, and even cheaply built rocket fighters to be employed. If take-off rockets are used, the aircraft's main engines can be designed exclusively for the requirements of climbing and cruising flight—ignoring take-off requirements—thus saving weight, fuel consumption, and cost.

From author's summary

3527. Tunnel Staff of Aero Department, R.A.E., and Brebner, G. G., Pressure and boundary layer measurements on a 59° sweptback wing at low speed and comparison with high speed results on a 45° swept wing, *Aero. Res. Counc. Lond. curr. Pap.* 86, 34 pp., 28 figs., Feb. 1949, published 1952.

The low-speed pressure distribution has been measured over a range of incidence on a 59° swept wing of symmetrical section, t/c 14%, aspect ratio 3.61, taper ratio 4 to 1.

These results have been compared, using the linear perturbation theory, with those on a 45° swept wing, aspect ratio 5.87 at $M = 0.8$. There is fairly good agreement at zero incidence, but lift distribution does not appear to be predicted so well.

The results on the 59° wing show clearly the large effects of sweepback on both the pressure distribution at zero incidence and the lift distribution near the center section of the wing. Comparisons with theoretical estimates at zero incidence show good agreement.

Measurements have been made of the boundary layer at the trailing edge of a 59° sweptback wing at low speed. The total head, velocity, and angle of flow have been found throughout the region in which these quantities differ from their free-stream values. A new type of yawmeter was used.

The displacement thickness and its associated loss of lift are considerable; they rise quickly with incidence and vary along the span. Thus, the spanwise loading will be quite different from that calculated on the basis of potential flow, even at comparatively small incidences. From authors' summary

3528. Hunn, B. A., A method of estimating the loading on an elastic airframe, *J. roy. Aero. Soc.* **56,** 496, 261–278, Apr. 1952.

Paper gives: (a) An adaptation of Multhopp's well-known solution of Prandtl's equation to the case of an elastic wing with known elastic influence function. The numerical constants involved herein are given in tables for both the symmetric and antisymmetric cases with 15 spanwise pivotal points. (b) A worked example on an unswept wing of aspect ratio 5.52. (c) Considerations on the possibility of applying the same principle to Multhopp's general theory of lift distributions [*RAE Rep.* no. Aero. 2353, 1950]. It appears that numerical applications are tedious and that Küchemann's semiempirical method [*RAE Rep.* no. Aero. 2392, 1950] must be preferred. (d) In an appendix, some problems are stated which arise in the application of the method referred to under (a) to the problem of rolling performance.

A. van Heemert, Holland

3529. Falkner, V. M., and Lehrian, Doris, Calculated loadings due to incidence of a number of straight and swept-back wings, *Aero. Res. Counc. Lond. Rep. Mem.* 2596, 8 pp., 41 tables, 3 figs., June 1948, published 1952.

Calculations are based on authors' vortex-lattice method. Results for the lift, local lift coefficient, loading coefficient, local aerodynamic center, induced drag, and, in some cases, the induced camber are given for the following wings: Twelve wings of constant chord, of aspect ratios 6, 4, 2, and 1 and with angles of sweepback 0, 30, and 45 deg; a triangular wing with 90-deg apex angle, aspect ratio 4; and two other wings derived from the latter by cropping the tips to reduce to aspect ratios 3 and 2.309, respectively. An additional investigation is made on the effect of the NACA camber on the properties at zero lift of a rectangular wing of aspect ratio 6. H. G. Loos, USA

3530. Andrew, G. M., and Polve, J. H., Frequency response of an airplane from flight-test data, *J. aero. Sci.* **19,** 4, p. 285, Apr. 1952.

By means of an approximate integration formula, known as trapezoidal rule, flight-test data are transformed into frequency response functions. Author indicates that use of six to ten ordinates leads to surprisingly satisfactory agreement with results based on as many as 80 ordinates and computed by means of automatic machines. J. R. M. Radok, England

3531. Oswald, T. W., The effect of nonlinear aerodynamic characteristics on the dynamic response to a sudden change in angle of attack, *J. aero. Sci.* **19,** 5, 302–316, May 1952.

Paper deals with the problem of removing some of the restrictions inherent in the classical methods of computing the dynamic response of an aircraft or missile. In order to determine the effects of nonlinear pitching moment and lift variations with angle of attack, author develops an approximate solution to the resulting nonlinear equation of motion. This solution is a step-by-step procedure in which the linearization is performed over a closed interval of the response variable. Knowledge of the dynamic behavior of the well-known linear oscillator then suffices to indicate the solution for the selected linearization interval. Several numerical examples (based on actual missile configurations) are considered, and the results of the approximate solution are compared with the accurate results of numerical integration, together with the solution yielded by the classical linear equations of motion.

Some discussion is given to the reverse dynamics problem, i.e., the determination of aerodynamic parameters from flight tests. Author concludes that extremely accurate instrumentation would be necessary in order to determine a nonlinear moment curve from flight-test data. Leonard Segel, USA

3532. Shapiro, J. S., Convertible aircraft, *Aeroplane*, pp. 412–415, 628–631, 42–45, Apr., May, July 1951.

In the first of three articles, author discusses some of the problems of convertible aircraft. In addition, a thorough review is presented of the various designs that have been proposed. Second article presents a discussion of specific civil and military uses for such aircraft. Finally, the performance of various convertiplane designs is investigated.

These articles, dealing with technical ideas far from practical execution, are, naturally, open to controversy; however, they do present the opinions of one who is well acquainted with the problems of convertiplanes. Leonard Goland, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 3382, 3509)

3533. Gayman, W. H., An investigation of the effect of a varying tip-weight distribution on the flutter characteristics of a straight wing, *J. aero. Sci.* **19,** 5, 289–301, May 1952.

Paper sketches over-all features of an extensive experimental investigation of the flutter of a straight wing having a tip fuel pod of varying geometrical and inertial characteristics. Model construction as well as instrumentation and test techniques are described, but no attempt is made to present and interpret sys-

tematically all the results of the more than 300 tests performed. One principal result is exhibited—the possible extreme sensitivity of flutter speed to tip-pod fuel content and distribution.

A complementary theoretical investigation is also summarized. Reliable prediction of flutter speeds was not achieved; author indicates that a successful theory may hinge largely on an adequate aerodynamic representation of the tip pod. Current efforts to deduce this representation are described.

B. Budiansky, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 3516, 3517, 3552)

3534. Stanitz, J. D., and Sheldrake, L. J., Application of a channel design method to high-solidity cascades and tests of an impulse cascade with 90° of turning, *NACA TN* 2652, 65 pp., Mar. 1952.

This is the application of Stanitz's methods of designing channels with prescribed wall-velocity distributions [AMR **5**, Revs. 1778, 1779] to the design of high-solidity cascades for prescribed conditions. The method is applicable to either incompressible flow or subsonic flow with $c_p/c_v = -1$. It is assumed that the "stagnation" streamlines upstream and downstream of the blades have constant velocity; this leads to cusped edges, which are later rounded off for practical use. A special type of velocity distribution on pressure and suction surfaces is treated. Limitations on maximum deceleration on the suction surface are introduced. A numerical example is given; the blade configuration obtained was tested in a cascade from Mach number 0.2 to choking. Measured velocity distributions are plotted in comparison with the prescribed ones. W. R. Sears, USA

3535. Bullock, R. O., and Finger, H. B., Surging in centrifugal and axial-flow compressors, *SAE Quart. Trans.* **6**, 2, 220–229, Apr. 1952.

Phenomenon of compressor surge is discussed. Experimentally determined characteristics of flow during surge are presented. General explanations of the causes of surge are given, based on test results and on an analysis of the momentum, continuity, and energy equations. Methods for improving compressor-surge characteristics are suggested. Stanley F. Gilman, USA

3536. Savage, M., and Beatty, L. A., A technique applicable to the aerodynamic design of inducer-type multistage axial-flow compressors, *NACA TN* 2598, 62 pp., Mar. 1952.

A method is presented for the preliminary design calculation of high pressure ratio, multistage, axial-flow compressors using the solid-body inducer-type design. A chart is included to facilitate design calculations. Based on the approximate computations, an investigation of the effect of various parameters on performance is carried out. The authors have made an evaluation of significant design trends as indicated by the analysis in the report. No experimental comparison is presented. J. F. Manildi, USA

3537. Hensley, R. V., Theoretical augmentation of turbine-propeller engine by compressor-inlet water injection, tail-pipe burning, and their combination, *NACA TN* 2672, 43 pp., Mar. 1952.

Paper deals with methods of augmenting turbine-propeller engines. Compressor-inlet water injection, tail-pipe burning, and combined water injection and tail-pipe burning are analyzed theoretically. Water injection is considered between sea level and 35,000 feet and for Mach numbers between 0 and 1.1. Tail-pipe burning is studied for altitudes up to 35,000 feet and for Mach numbers between 0.6 and 1.1. Combined effect is determined at 35,000 feet and for Mach numbers between 0.9 and 1.1. Compressor performance characteristics typical of axial-flow compressors are used, and saturation at compressor inlet is assumed. It is shown that, under all conditions, augmentation by water injection is superior and that the combined effect is greater than additive. It is shown that variations in ambient relative humidity have little effect on augmentation with water injection.

Paper is important because recent improvements in high-speed propellers may lead to wider usage of turbine-propeller-driven aircraft. A. B. Cambel, USA

3538. Stehling, K. R., Injector spray and hydraulic factors in rocket motor analysis, *J. Amer. Rocket Soc.* **22**, 3, 132–138, May-June 1952.

Qualitative summary of characteristics of rocket nozzles and of tests on nozzle flow and stability. M. P. O'Brien, USA

3539. Wu, C.-H., and Brown, C. A., A method of designing turbomachine blades with a desirable thickness distribution for compressible flow along an arbitrary stream filament of revolution, *NACA TN* 2455, 45 pp., Sept. 1951.

Authors have attacked problem of obtaining rapid solution of turbomachinery blade profiles for steady two-dimensional compressible subsonic potential flow, given the inlet and exit angles and certain geometrical limitations, such as the distribution of blade thickness. A mean streamline is first assumed. Velocity components and density on this streamline are calculated, and then their variation in the pitch direction is obtained by using a rapidly converging power series. Numerical calculations appear to be rapid for their illustrative examples—16 hr for one compressible-flow solution. By assuming different mean streamlines, or by permitting the mean streamline to divide the flow unequally in the channel, a number of possible blade profiles will be obtained. Authors suggest that the best design be chosen empirically on the basis of velocity distribution on the blades, but this criterion is not discussed.

The method can be applied to axial-flow, radial-flow, and mixed-flow turbomachines, since the surface of revolution on which the blades are located is arbitrary. Reviewer would caution the designer that the assumptions of nonviscous fluid and stream filling the channel (no separation) may be serious limitations in certain applications. P. R. Trumpler, USA

3540. Schweitzer, P. H., Research in exhaust manifolds, *Trans. ASME* **74**, 4, 517–528, May 1952.

Over a period of four years, author has investigated the effect of the exhaust manifold on engine performance, particularly in two-stroke-cycle multicylinder engines. Some aspirator-type manifolds create suction rather than back pressure, and result in scavenging-air flows that are greater than obtainable not only with conventional manifolds but even with no manifolds at all.

From author's summary

Flow and Flight Test Techniques

(See also Revs. 3491, 3527)

3541. Chevallier, J.-P., Techniques and results of tests in the domain of transonic velocities (in French), *Actes Coll. inter. Mécan.* **II**, *Publ. sci. tech. Min. Air, Paris* no. 250, 157–179, 1951.

Paper presents a brief review of the techniques that have been investigated and adopted by ONERA for deriving aerodynamic characteristics of models at Mach numbers including transonic speeds. The techniques are well known and include the use of

the "bump" and slotted walls for transonic speeds and the base plate of variable inclination developed by Drougge of Sweden for supersonic speeds. There is much emphasis on value of half-model tests in this connection and the possibilities of testing the same half model throughout the Mach number range. A few sample test results are presented, but there is no indication as to how the results of the various methods compare in the interesting transonic region. A. D. Young, England

3542. Gratzer, L. B., Design of a new balance system for the Kirsten wind tunnel, *Trend Engng. Univ. Wash.* **4,** 3, 13–16, July 1952.

A description is given of a six-component wind-tunnel balance mounted on flexure pivots. Balancing of the forces transmitted through bell cranks is accomplished electromagnetically, and the coil-current reading provides a measure of the load. A development is given of moments of force acting in the lever system.
H. M. Spivack, USA

3543. Lina, L. J., and Trant, J. P., Jr., Comparison of airspeed calibration evaluated by the accelerometer and radar methods, *NACA TN* 2570, 16 pp., Jan. 1952.

A calibration of the Pitot-static airspeed installation on a jet fighter airplane was made to compare the accelerometer method of determining static-pressure error with the radar method. The radar method makes use of measurements of static pressure recorded in the airplane and of geometric height as determined by recording radar-phototheodolite equipment on the ground. In the accelerometer method, free-stream static pressure is computed from measurements of pressure, measurements of temperature, and changes in geometric height determined by integrations of accelerometers carried by the airplane. The tests included shallow dives up to a Mach number of about 0.80 with pull-ups of about 4, 3, and 2g normal acceleration.

The results of the tests indicated that, for vertical plane maneuvers, the accelerometer method may be used as an alternate to the radar method. Although the accelerometer method requires airplane instrumentation of fairly high precision, this equipment may be more generally available than the radar equipment.
From authors' summary

3544. Helfer, A. P., Electrical pressure integrator, *NACA TN* 2607, 44 pp., Jan. 1952.

The design of an instrument utilizing Wheatstone-bridge type of pressure-sensing units that is capable of integration of airfoil pressures into a quantity representative of the normal force and pitching moment acting on the airfoil is presented. Subsequent division of the integrator output by dynamic pressure q results in normal force and moment coefficients c_n and c_m without the need for lengthy manual integrations of manometer data. Flight and wind-tunnel versions of this instrument are briefly described, along with samples of test data obtained from them. Design equations are presented, and factors affecting instrument accuracy are discussed. From author's summary

3545. Glaser, A. H., The Pitot cylinder as a static pressure probe in turbulent flow, *J. sci. Instrum.* **29,** 7, 219–221, July 1952.

A simple static-pressure probe is described which will give good accuracy in a fixed position in a natural wind of rapidly varying direction and speed. It is in the form of a long cylinder with two radial holes separated by a critical angular distance. The static pressure is obtained as the average of the pressure on the two holes, the average being formed by equal capillary resistances between each hole and the common tube to the manometer.
From author's summary

3546. Duquenne, R., On the analogy calculation for lifting surfaces (in French), *C. R. Acad. Sci. Paris* **234,** 22, 2150–2152, May 1952.

Paper describes a slight modification in the technique used with the lifting-surface analogy [see AMR **5,** Rev. 1528]; for wings with uniform angle of attack (flat plates), this modification permits a simpler and more rapid solution. Results are presented for a circular, a square, and a delta wing and are shown to be in good agreement with results obtained analytically by the methods of Kinner, Falkner, and Berndt, respectively.
F. W. Diederich, USA

3547. Loos, H. G., Tunnel-wall interference for aerofoils and aerofoil-fuselage combinations in a tunnel with an octagonal section for incompressible flow, *Nat. LuchtLab. Amsterdam Rap.* A.1204, 9 pp., 1952.

The interference between wing-tip vortexes and the walls of an octagonal wind tunnel is treated by replacing the horizontal and vertical walls by the usual image, as in conventional wall-interference calculations for rectangular tunnels, and by replacing the oblique walls by quadrupoles with a suitably chosen strength. An approximate image method is applied to calculate the downwash correction for the interaction of a cylindrical fuselage-wing combination and the tunnel. H. J. Allen, USA

3548. Ruptash, J., Boundary layer measurements in the UTIA 5 by 7 inch supersonic wind tunnel, *Inst. Aerophys. Univ. Toronto UTIA Rep.* no. 16, 20 pp., 3 tables, 23 figs., May 1952.

An approximate calculation by standard procedures is given for the development of the compressible turbulent boundary layer in a Mach 3 nozzle. The Blasius skin-friction law with wall density and viscosity is used.

The experimental Mach number distribution along the nozzle was in very good agreement with theory. A series of boundary-layer total-pressure surveys were made from which velocity and Mach number distributions were obtained to compare with theory. Author concludes theory gives satisfactory results if a reliable shearing-stress law is used. Schlieren and tuft studies of the flow are also included.

Reviewer believes report to be a valuable addition to the scanty available experimental data. William Squire, USA

Thermodynamics

(See also Revs. 3430, 3538)

3549. Aubert-Huetz, Madeleine, Realization of measurement of the ratio of specific heat of gases (in French), *C. R. Acad. Sci. Paris* **235,** 1, 25–27, July 1952.

Specific heat ratios are measured of benzene, hexane, and heptane at 125 C and 1 atm pressure, values being, respectively, 1.07, 1.13, and 1.06. Method consists of an oscillating liquid column in a U-shaped tube which is connected at both ends to reservoirs containing the gas under investigation. From the oscillation period ratio γ can be derived.
K. W. Taconis, Netherlands

3550. Keenan, J. H., Properties of the gases of combustion processes, *Engineering* **172,** 4468, 4469; 347–348, 379–382; Sept. 1951.

Paper reviews recent experimental, theoretical, and tabulatory work done in the United States on the properties of gases, with particular emphasis on monatomic and diatomic gases and water vapor. Topics from about 20 recent papers (most of which are published in *Trans. ASME*) are reviewed, including: Calculations

of thermodynamic data from band spectra observations; evaluation of the equation of state by p, V, T measurements and Joule-Thomson methods; evaluation of force constants between molecules; transport phenomena, including recent measurements of viscosity and heat conductivity of gases. Paper is taken from the Herbert Akroyd Stuart Memorial Lecture given by Professor Keenan at Nottingham University, May 10, 1951, and is written for an audience of engineers interested in having exact compilations of thermodynamic data regarding gases used in combustion processes. J. G. Daunt, USA

3551. Mullen, J. W., II, Fenn, J. B., and Irby, M. R., The ignition of high velocity streams of combustible gases by heated cylindrical rods, Third Symp. Comb. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 317–329, 1949. $13.50.

Paper presents and discusses the effect of a number of variables on the surface temperatures required of a small metal rod heated over a $^1/_4$-in. span to ignite combustible gaseous mixtures flowing perpendicular to it. Increasing the stream velocity (50 to 500 fps), the turbulence level, or the specific humidity increased the surface temperature of the rod required for ignition. Increasing the pressure (10 to 30 psi gage) or the rod diameter ($^1/_{16}$ in. to $^1/_4$ in.) decreased the rod temperature required for ignition. The rod surface temperature for ignition experienced a minimum near stoichiometric with changes in fuel concentration, were unaffected by the physical nature of the rod surface, were higher for platinum rods than for stainless-steel rods, and were progressively higher as more and more of the heated area on the downstream side of the rod was reduced with the aid of the Transite inserts. An explanation is offered, based on the idea that the increment of fuel-air mixture that is to ignite is heated to an "ignition temperature" that is directly proportional to a contact time in the eddy behind the rod and to the difference between the rod surface temperature and the stream temperature. The contact time is directly proportional to rod diameter and inversely proportional to stream velocity; contact time must also satisfy "ignition lag." W. T. Olson, USA

3552. Traupel, W., Efficiency of thermal engines (in Swedish), *Tekn. Tidskr.* **80,** 46, 1157–1164, Dec. 1950.

From the point of view of thermodynamics of irreversible processes [Prigogine, AMR **5,** p. 193], author analyzes and compares efficiencies and other characterizing factors of heat engines (spark ignition, diesel, reciprocating steam, gas turbine, steam power plant) resulting in predictions about their future development and application.

Gillis Huss, Sweden

3553. Meixner, A., Flow of fluid media with internal transformations and pressure viscosity (in German), *Z. Phys.* **131,** 4, 456–469, 1952.

Assuming slight deviation from thermodynamic equilibrium, so that methods of the thermodynamics of irreversible processes [DeGroot, AMR **5,** Rev. 240] can be applied, author calculates effect of one or two inner degrees of freedom (relaxation and/or chemical reaction) upon equations of hydrodynamics. Use of the Gibbs relation for the entropy change as well as Onsager's reciprocal relation leads to a correction to the pressure term which involves two parameters, each of which has associated with itself a relaxation time. One is the "second viscosity" coefficient which the author calls "pressure viscosity," but the second one is new and not amenable to physical interpretation. While expressions for these parameters are derived, no numerical calculations (and hence check with experiment) are given.

R. E. Street, USA

3554. Kampé de Fériet, J., Statistical mechanics of a continuous medium (vibrating string with fixed ends), Berkeley, Los Angeles; Univ. Calif. Press, Proc. Second Berkeley Symp. Math. Statistics and Probability, 1950, 553–566, 1951. $11.

In order to ultimately treat turbulence by statistical mechanics, a simpler system, also of infinite degrees of freedom, is considered. The problem is to establish a phase space, a flow of the space into itself, an ergodic theorem (existence of time averages along a trajectory), an invariant measure, and to determine the indecomposable (metrically transitive) subspaces.

Consider $y_{xx} = y_{tt}$, $0 \leqq x \leqq l$, $y(0, t) = y(l, t) = 0$, $v = y_t$. At a given instant, the state of the string, $y(x)$, $v(x)$, can be represented by a single $2l$-periodic function $f(x)$: $f(x) = \frac{1}{2}[y'(x) + v(x)]$, $0 \leqq x \leqq l$; $f(x) = \frac{1}{2}[y'(-x) - v(-x)]$, $-l \leqq x \leqq 0$; $y(x) = -\int_x^z f(s)ds$, $v(x) = f(x) - f(-x)$. The phase space is all continuously differentiable $2l$-periodic functions $f(x)$ subject to $\int_0^{2l} f(s)ds = 0$. Since the solution of the differential equation is $y(x, t) = -\int_x^z f(s + t)ds$, the transformation of the phase space is $T_t f(s) = f(s + t)$. The periodicity of f implies that each trajectory is a closed curve. It follows trivially that the infinite time average exists for each trajectory; all invariant measures are evident; the only indecomposable subspaces are the individual trajectories, and time averages are equal to phase averages only in the trivial case of a measure concentrated on a single trajectory. For the proof, introduce the measure space $B \times C$, B arbitrary and C a circle, $\beta \epsilon B$, $\gamma \epsilon C$. To every function $g(\beta, \gamma)$ measurable in β, continuously differentiable and periodic in γ with $\int_0^{2l} g(\beta, \gamma)d\gamma = 0$, a measure is defined on $f(s) = g(\beta, \gamma + s)$. A correlation function and the average values of several moments are computed.

Courtesy of Mathematical Reviews H. Grad, USA

3555. Johnson, M. H., Diffusion as hydrodynamic motion, *Phys. Rev.* (2) **84,** 3, 566–568, Nov. 1951.

Author considers a mixture of perfect gases, all having the same local temperature but different densities and pressures; $p_r = n_r kT$, $p = \Sigma p_r$, $n = \Sigma n_r$. A phenomenological equation stating the conversation of momentum for each component is postulated

$$-\frac{\partial p_r}{\partial \mathbf{r}} + \rho_r(\mathbf{F}_r - \mathbf{a}) + n_r \sigma_r \bar{\mathbf{c}}_r \times \mathbf{H} = \sum_s \theta_{rs}(\bar{\mathbf{c}}_r - \bar{\mathbf{c}}_s) \qquad [*]$$

($\bar{\mathbf{c}}_r$ is used here for the author's $(\bar{\mathbf{c}}_r)_{\mathrm{Av}}$, the mean velocity of species r). The right-hand side represents a frictional force between components r and s proportional to their relative velocity. Newton's third law takes the form $\theta_{rs} = \theta_{sr}$. The coefficient θ_{sr} is assumed to be a function of n_r and n_s only. If a single species r is subdivided arbitrarily into components (all at the same temperature T), condition [*] on these subcomponents implies that $\theta_{rs}/n_r n_s$ is a constant for the two species r and s. The formula [*] is shown to be consistent with a certain (primitive) approximation obtained from the Boltzmann equation by Chapman, namely

$$-\frac{\partial p_r}{\partial \mathbf{r}} + \rho_r\left(\mathbf{F}_r - \frac{D_0 \mathbf{C}_0}{Dt}\right) + n_r \sigma_r \bar{\mathbf{C}}_r \times \mathbf{H} = \sum_s (kT(n_r + n_s)^{-1} n_r n_s / [D_{rs}]_1)(\bar{\mathbf{C}}_r - \bar{\mathbf{C}}_s)$$

It is incorrectly stated that more subtle diffusion phenomena (e.g., thermal diffusion) cannot be accounted for by a simple modification of [*] keeping the right-hand side a sum of binary terms. The right-hand side will always be a sum of binary terms for a perfect gas if, instead of identifying the acceleration $\mathbf{a}$ with $D\mathbf{c}_0/Dt$, the acceleration of the mean motion ($\rho \mathbf{c}_0 = \Sigma \rho_i \mathbf{c}_i$), it is identified with $D\bar{\mathbf{c}}_r/Dt$, the acceleration of the rth component

itself. Details can be found in an unpublished thesis by I. Kolodner [New York University, 1950].

Courtesy of Mathematical Reviews H. Grad, USA

Heat and Mass Transfer

(See also Revs. 3459, 3589)

3556. Surinov, Yu. A., Solution of a mixed problem of radiative heat transfer for a sphere (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **83,** 1, 75–78, Apr. 1952.

In this paper, author considers the stationary mixed problem for a sphere (filled with a diathermal medium) with a grey surface F which consists of two regions F_1 and F_2 such that $F = F_1 + F_2$. An arbitrary distribution of temperature is given in the region F_1, the density of the resultant radiation is given on F_2, and certain optical constants are given for the entire surface F. It is required to determine the fields of the densities of the various types of radiation on the surface as well as in the interior of the sphere. Because of the geometric simplicity of the configuration, author is able to obtain an exact solution of the problem by elementary methods based on the classification of the types of radiation given in some of his earlier papers [AMR **4,** Rev. 3704].

Courtesy of Mathematical Reviews H. P. Thielman, USA

3557. Bergelin, O. B., Brown, G. A., and Doberstein, S. C., Heat transfer and fluid friction during flow across banks of tubes. IV. A study of the transition zone between viscous and turbulent flow, Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper 51—A-109, 5 pp., 3 tables, 11 figs.

Results of heat transfer and pressure drop are presented for five tube banks in cross flow. Tubes were $^3/_8$ in.-OD with equilateral triangular spacing, staggered square, and in-line square spacing with pitch-to-diameter ratio equal to 1.25; and equilateral triangular and staggered square spacing with pitch-to-diameter ratio equal to 1.5. Pressure-drop data were obtained for isothermal, heating, and cooling runs with a light oil on the outside of the tubes for Reynolds number (based on outside tube diameter) range from 25 to 10,000. For heat transfer, Reynolds number range was the same. The heat-transfer coefficients were between 28 and 632 Btu per hr sq ft F.

Compared with Chilton and Genereaux's method, without viscosity correction, the friction factors for cooling are somewhat greater than for isothermal flow, and somewhat lower during heating. Also, the Gunter and Shaw method cannot be said to represent all arrangements in the transition zone. From velocities of 0.1 to 0.5 fps, heat-transfer coefficients for the in-line banks fall far below those for the staggered banks. The relative performance in the range 0.5 to 2 fps improves some for the in-line banks, but they are never as high as for the staggered banks.

Byron E. Short, USA

3558. Véron, M., Thermic fields and heat flow; graphic and related methods (in French), Soc. Franç. Construct. Babcock Wilcox, Paris, 281 pp., 1950–1951.

A comprehensive collection of graphical solutions to problems of heat transfer in one, two, and three dimensions. Steady- as well as nonsteady-state problems are discussed in equal detail. Author has carefully paralleled the theory with various graphical solutions which sometimes are definitely necessary due to lack of theoretical means of solutions and also often necessary for designers of heat-transfer equipment.

Chapter I introduces the fundamental concepts of the transfer of heat. Equations governing the transfer of heat by conduction are derived in three orthogonal coordinate systems. Isothermal and equipotential functions are defined and conditions for their orthogonality are discussed.

Chapter II introduces simple graphical methods for solving one-dimensional steady-state problems of heat transfer by convection and radiation between fluids and flat, cylindrical, and spherical walls. The problems discussed assume simple boundary conditions encountered in heat exchanges. This chapter contains relaxation methods for two- and three-dimensional problems.

Graphical methods for one-, two-, and three-dimensional nonsteady-state problems of conduction are clearly presented in Chapter III. Author sets up finite difference equations $\Delta\tau_n/\Delta t = (2\lambda/c\rho)[(\tau_{n-1} + \tau_{n+1})/2 - \tau_n/\Delta\bar{x}^2]$ instead of the continuum equation $\partial\tau/\partial t = (\lambda/c\rho)\partial^2\tau/\partial x^2$. Flow of heat through cylinders and spheres is treated as well, and problems with periodically pulsating boundary conditions are solved.

Chapter IV is devoted to numerous electrical-analog solutions for nonsteady-state problems of conduction in one, two, and three dimensions. This chapter contains many equivalent circuits to interesting problems in heat flow.

Next chapter treats analytically and graphically problems with time-dependent boundary conditions. The graphical solutions become somewhat involved due to the fact that the solutions to these problems are in the form of integral equations.

Applications of all the methods described in previous chapters are combined in Chapter VI to solve engineering problems in heat transfer.

The notations and symbols are somewhat unfamilar to American readers on this subject. S. Eskinazi, USA

3559. van Deemter, J. J., On the theory of the Ranque-Hilsch cooling effect, *Appl. sci Res. (A)* **3,** 3, 174–196, 1952.

An extended Bernoulli equation, adapted to turbulent flow, is applied to a model of the rotational flow in the Ranque-Hilsch vortex tube. It is shown that on the basis of this model a reasonable quantitative explanation of the cooling effect can be given. The experimental results of Hilsch and Elser and Hoch agree for the greater part with this theory.

From author's summary by S. A. Schaaf, USA

3560. Nelson, H. M., Temperature distribution with simultaneous platten and dielectric heating, *Brit. J. appl. Phys.* **3,** 3, 79–86, Mar. 1952.

Analytical solution is given for temperature distribution in solid of infinite extent bounded by two parallel planes in which heat is being uniformly generated and the surfaces of which are maintained at an elevated temperature θ_1, while solid is initially at uniform temperature θ_0 throughout. Three special cases of general solution are considered: (1) Temperature distribution with lower temperature limit; (2) temperature distribution with minimum variation about mean; and (3) optimum conditions required for uniform setting of synthetic resins and adhesives for which setting time is function of temperature. Results show that combined heating compared with platten heating alone involves time gain of the order of 10:1 for permissible temperature variation across material of 20%, and 2.5:1 for permissible variation of 1.2%. Graphical representation of results facilitates calculation of parameters for optimum conditions. Actual choice of parameters is restricted by certain practical considerations which are mentioned. A. H. Žaludová, Czechoslovakia

3561. Verbeck, G. J., and Hass, W. E., Dilatometer method for determination of thermal coefficient of expansion of fine and coarse aggregate, Highway Res. Bd.; Proc. 30th ann. Meeting, 187–193, 1951.

The durability of concrete subjected to temperature variations

may be related to the therma coefficients of expansion of the aggregate and the cement paste. Authors describe a method for determining the cubical coefficients of expansion of sand and coarse aggregate. Results of determinations on various other materials (pyrex, copper, and quartz) are tabulated and the values compared to known coefficients for those materials. There is close agreement between the values already known and those determined by this method.

The method consists of measuring the change in volume displacement of the material for a controlled and accurately measured temperature change. The sample of dried aggregate is placed in a one-liter dilatometer flask, which is then filled with air-free water. The flask is immersed in a water bath whose temperature is controlled to produce expansion of the water from the flask into an attached capillary tube which is connected to a mercury reservoir. The thermal-expansion of the water and aggregate displaces the mercury from its reservoir to the bottom of a calibrated volume chamber. Temperature equilibrium is attained at this position, and the temperature measured with a Beckman thermometer. The temperature is then increased until the mercury reaches the top of the calibrated volume and, after equilibrium is reached, the temperature is measured.

Once the volume and coefficient of expansion are determined for the flask itself, the cubical coefficient of an aggregate can be calculated, knowing the mass of the water in the flask and the temperature rise required to obtain the known volume change.

The bath temperature is maintained by electric heating elements actuated by contacts at the low-level and high-level mercury positions in the calibrated volume chamber. Thus, temperature equilibrating before and after the measured expansion is done automatically. S. Zivi, USA

3562. Estermann, I., and Weertman, J. R., Specific heat of germanium between 20° K and 200° K, *J. chem. Phys.* **20,** 6, 972–976, June 1952.

High-precision measurements of the specific heat of germanium were carried out in the temperature region between 20 K and 200 K. Three samples of germanium were investigated: An extremely pure sample; one of intermediate purity (10^{13} impurity centers/cm^3); and one with an addition of 0.006 atomic % aluminum (2×10^{20} impurity centers/cm^3). No anomaly such as reported by Cristescu and Simon was found in any of the samples. However, a small dependence of the specific heat on the concentration of impurity centers was observed.

From authors' summary

3563. Garbett, C. R., The transient method for determining heat transfer conductance from bodies in high velocity fluid flow, Heat Transfer Fluid Mech. Inst., Stanford Univ., 107–119, 1951.

Utilization is made of the transient technique for deducing the steady-state heat-transfer coefficients for wedges in supersonic flow provided by a blow-down wind tunnel. Test results are presented in the usual manner, plotting Stanton's number multiplied by the $^2/_3$ power of the Prandtl number against the onstream Reynolds number. The data show a measure of correlation on this basis, but the large size of the wedge in terms of the test section prohibits an exact specification of the flow conditions. Errors in method are discussed with regard to thermal and flow systems. R. M. Drake, Jr., USA

3564. Schultz, B. H., Approximative formulae in the theory of thermal regenerators, *Appl. sci. Res.* (A) **3,** 3, 165–173, 1952.

Heat exchange in regenerators is governed by Hausen's differential equations $\Theta_x = -\Gamma T_\tau = \Lambda(T - \Theta)$, determining the temperature of the gas Θ and matrix T as functions of the reduced coordinate and time x and τ, with the reduced length Λ and the ratio of heat capacities matrix/gas Γ as parameters. Analytic and numerical methods of solution as given by Hausen and others are cumbersome; available data are frequently insufficient. For the limit of vanishing blow period (recuperator), a simple solution is known; author uses this as starting point for a method of successive approximation yielding T and Θ in the form of a power series in either $1/\Gamma$ or Λ. The latter expansion applies to short (low-efficiency) regenerators and is only of limited use. Expansion in powers of $1/\Gamma$ applies to short blow periods. For regenerators of medium length, $\Lambda \leq 50$, the second approximation provides concise, useful formulas of fair accuracy. If regenerators of greater length are considered, higher approximation is required and the method becomes unwieldy. The paper is supplemented by graphs and tables.

R. Eisenschitz, England

Acoustics

3565. Rust, H. H., and Bailitis, E., Linear magnetostrictive ultrasound generation by means of a magnetic cross field (in German), *Acustica* **2,** 3, 132–135, 1952.

In order to avoid the remanence-conditioned loss of amplitude in ultrasonic generators employing the longitudinal magnetostrictive effect, authors suggest combining the longitudinal effect with the transverse magnetostrictive one. For this purpose, two sets of coils normal to each other are arranged on the magnetostrictive body, each set consisting of a double coil, one for the direct, the other for the alternating current. By suitable choice of current strength, the vectors of the ferromagnetic domains rotate and the remanence will vanish. By this method, sound generators of nickel have four times higher amplitudes. Furthermore, the application of cheaper materials with smaller magnetostrictive effects, e.g., iron-nickel or iron-silicon alloys, becomes possible.

Margot Herbeck, Germany

3566. Parbrook, H. D., and Richardson, E. G., Propagation of ultrasonic waves in vapours near the critical point, *Proc. phys. Soc. Lond.* (*B*) **65,** part 6, 390B, 437–444, June 1952.

An experimental study is made of the velocity and absorption of ultrasonic waves in carbon dioxide and ethylene at frequencies between $^1/_2$ and 2 mcps and at pressures up to 100 atmospheres in a variable-path acoustic interferometer. At pressures above 10 atmospheres, the results are independent of frequency (in this range) in the gaseous phase. The velocity and absorption coefficient reach a minimum near the condensation point, but, especially at the critical point itself, have high and indeterminate values when the change of phase takes place. The ultrasonic viscosities calculated from these measurements are of the order of 1000 times those derived from transpiration or low-frequency oscillation experiments. From authors' summary

3567. Stewart, Ellen S., and Stewart, J. L., Rotational dispersion in the velocity, attenuation, and reflection of ultrasonic waves in hydrogen and deuterium, *J. acoust. Soc. Amer.* **24,** 2, 194–198, Mar. 1952.

A brief theoretical treatment is given of dispersion in the velocity, attenuation, and reflection of sound waves in a gas. Then data are presented on the observed dispersion of the velocity of sound and on the effect of impurities upon the rotational relaxation times determined therefrom. The attenuation is shown to agree with the theory, with some evidence of multiple relaxation times. Anomalous dispersions of classical attenuation and of the

Herzfeld reflection coefficient are predicted. The latter is confirmed experimentally and also yields a determination of the accommodation coefficient. W. H. Pielemeier, USA

3568. Glass, I. I., On the speed of sound in gases, *J. aero. Sci.* **19,** 4, 286–287, Apr. 1952.

Speed of sound in air, argon, and carbon dioxide is determined by measuring speed of head of the rarefaction waves in a shock tube. Results are in good agreement with the values obtained from acoustic methods and from isentropic theory. Experimental arrangement and accuracy of method are briefly described. H. J. Ramm, USA

3569. Labhart, H., Sound velocity in porous media (in German), *ZAMP* **3,** 3, 205–211, May 1952.

Author investigates dependence of speed of sound on porosity for application to design of resonators of barium titanate or ferrites. Experimental material in a series of rods of (magnetostrictive) nickel-zinc ferrite (20% zinc ferrite) was sintered at various temperatures to produce porosities of from 4 to 26%. Speed of sound is obtained from rod resonance in magnetic field. Theoretical value is developed from usual formula but containing an elastic modulus obtained from a rough theory. Theory agrees well with experiment if pores are assumed more nearly spherical for low than for high porosities. Martin Greenspan, USA

3570. Nyborg, W. L., Burkhard, M. D., and Schilling, H. K., Acoustical characteristics of jet-edge-resonator systems, *J. acoust. Soc. Amer.* **24,** 3, 293–304, May 1952.

Experimental results are given for jet-edge systems, which consist of a thin stream of air from an orifice impinging against a knife edge. Edge tone fields are discussed in terms of pressure magnitude and distribution-in-space, frequency range, and flow rate. The concept of a modulation coefficient and an empirical formula for frequency are explained. Application to resonator-type whistles is given. E. G. Fischer, USA

3571. Fox, E. N., The diffraction of a plane sound pulse incident normally on a regular grating of perfectly reflecting strips, *Proc. roy. Soc. Lond.* (*A*) **211,** 1106, 398–417, Mar. 1952.

Paper continues author's theoretical work on diffraction of plane pulses and should be read along with his earlier papers [AMR **2,** Rev. 528; **3,** Rev. 1375]. In these he gives a method of reducing the problem to an integral equation of quasi-Wiener-Hopf type, and solves it by successive approximations using a Laplace transformation.

The physical results obtained from the exact and asymptotic solutions to the grating problem of the present paper show that, at the back of the grating, the average pressure overshoots the steady value by not more than 10%, whatever the ratio β of slit width to grating constant. The asymptotic solution is a good approximation to the exact value if $\beta < 0.25$. At large distances from the grating, the maximum overshoot of the pressure in the transmitted pulse occurs for β equal to 0.5, and is then about 6% larger than the steady value. J. M. Jackson, Scotland

3572. Schoch, A., Sound reflection, sound refraction, and sound diffraction [Schallreflexion, Schallbrechung und Schallbeugung], Berlin Springer-Verlag, Ergebn. exakt. Naturw. **23,** 127–234, 1950.

This monograph is a valuable addition to the literature of the theory of sound waves of small amplitude, either in a gas or in an elastic solid. The scope of the work is best indicated by the titles of the chapters, viz.: (I) Introduction; (II) Foundations of the theory; (III) Reflection and refraction of a plane wave at a plane boundary surface; (IV) Free boundary-layer waves along a plane boundary surface; (V) Reflection and refraction of nonplane waves at a plane boundary surface; (VI) Waves in plates; (VII) Layered media; (VIII) Curved boundary surfaces and diffraction phenomena; (IX) Bibliography. The bibliography should prove most useful, as it contains 144 references, nearly half of them to work done since 1945. While the work is essentially mathematical, it contains many beautiful photographs of experiments illustrating the theory.

Courtesy of Mathematical Reviews E. T. Copson, USA

3573. Twersky, V., Multiple scattering of radiation by an arbitrary planar configuration of parallel cylinders and by two parallel cylinders, *J. appl. Phys.* **23,** 4, 407–414, Apr. 1952.

In AMR **5,** Rev. 1892, reviewer pointed out that the generality of the paper reviewed there would serve as a source of further, more specialized results. This paper considers the case when the axes of parallel cylinders lie in the same plane. The two-parallel-cylinder problem is worked out with the case of the incident wave polarized perpendicularly to the elements receiving more detailed attention. The Rayleigh approximation solutions are presented. K. M. Siegel, USA

3574. Junger, M. C., Sound scattering by thin elastic shells, *J. acoust. Soc. Amer.* **24,** 4, 366–373, July 1952.

Cylindrical and spherical shells freely suspended in a fluid (for which the simplified wave equation holds) are treated for an incident plane wave; the dynamic deflections and the thickness of the shells are assumed small compared to their diameters. The analysis correlates the general solution of the wave equation in the fluid with the Lagrange equations of motion for the shell. Two simultaneous equations are obtained; one, by equating the total sound pressure integrated over the surface of the shell to the generalized forces on the shell; and the other, by requiring that the normal surface displacement of the shell equal the normal particle displacement at its boundary. Solution of these equations yields the scattered sound pressure. In distinction to solid scatters, the dynamic characteristics of the shell immersed in a fluid differ markedly from those in a vacuum. Thus, certain natural frequencies of the shell may be greatly reduced, and a damping effect may occur to limit the response and lower the frequency selectivity at resonance. Vic Twersky, USA

Ballistics, Detonics (Explosions)

3575. Michel, J. G. L., Direct calculation of smooth gunnery range tables, *Quart. J. Mech. appl. Math.* **5,** part 1, 124–128, Mar. 1952.

As opposed to the slow and awkward practice of inverse two-variable interpolation, the author proposes a device for inverting any pair of nonlinear functions of two variables, to use the linearity of the relationships among the differentials, and by integration of the inverse of the Jacobian to obtain the desired inverse pair. He illustrates the value of this method for a typical problem of ballistics. A. A. Bennett, USA

3576. Capra, V., On the integration of differential equations of ballistics by means of nomograms (in Italian), *Univ. Politecn. Torino R. C. Sem. Mat.* **10,** 235–241, 1 plate, 1951.

The author assumes ballistic equations with exponential air density (ignoring temperature effects upon the Mach number). As independent variable, he adopts log tan $(\pi/4 + \theta/2)$, the familiar antigudermannian of the angle of inclination. He constructs a

nomogram with 5 vertical and 7 horizontal scales, by means of which one may obtain successive tangents enveloping the trajectory. Four curves are to be thus plotted. Straight edges must be used not only to join finitely accessible points, but also to draw vertical and horizontal lines as usual in analytic geometry. The author prefers graphical to numerical methods.

A. A. Bennett, USA

3577. Mosséen, U., About sighting in wind and height estimation (in Swedish), *Artill. Tidskr.* **81**, 3, 86–95, 1952.

Author has statistically analyzed 177 optical sightings in the wind and compared the obtained values with those from height-estimation tables. The time intervals between the sightings were 15–30 min and lasted up to $3^1/_2$ hr. The divergence of each sighting and estimated table value from the arithmetic value of the sightings have been graphically determined for every 100 m up to 3000-m height.

Results:	Wind force (m/s) — Observations	Wind force (m/s) — Calculated	Wind direction (degrees) — Observations	Wind direction (degrees) — Calculated
Root mean square error (σ)	1	2	12	28
Probable error (ρ)	0.8	1.4	8	19

A comparison between the most diverging individual sighting and estimated table values proves a remarkable superiority of the sighting. For artillery, author nevertheless does not recommend re-introducing the optical sighting of wind owing to the great inconvenience of this method in the field. But neither can he accept the lack of exactness in the height estimation.

Ragnar Sjöberg, Sweden

3578. Rinehart, J. S., Allen, W. A., and White, W. C., Phenomena associated with the flight of ultra-speed pellets. Part III. General features of luminosity, *J. appl. Phys.* **23**, 3, 297–299, Mar. 1952.

Continuation of series [AMR **5**, Revs. 1894, 2512] deals with general features of luminosity. Flashing, brightness, temperature, and dependence of luminosity on such factors as material and velocity are discussed. Photographs indicate that flashing (as observed in meteors) is caused by yawing of the pellet. Authors conclude that material is removed from pellet in form of small droplets and that subsequent burning of material is primary source of light. By photographic comparison with sun and commercial photoflash bulb, the following approximate measurements were obtained: Brightness, 25,000 lamberts; luminous output, 30,000 lumen-seconds; color temperature, 2900 K.

Robert M. Stewart, USA

3579. Sutton, G. P., Rocket propulsion elements. An introduction to the engineering of rockets, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1949, ix + 294 pp. $5.

Most of the available literature on rockets tends to have been written for consumption by the science-fiction set. The present book is an exception. As implied by its title, it is concerned with the most important engineering considerations in rocket-motor design, operation, and evaluation. Little or no discussion is devoted, however, to the aerodynamic, structural, and control problems of rocket vehicles. It has, within the reviewer's knowledge, been used successfully as an introductory textbook in classes at several colleges and other organizations. There is more emphasis on basic principles and less on technical detail than in Zucrow's book ["Principles of jet propulsion and gas turbines," John Wiley and Sons, New York, 1948]. Realistic problems are included at the end of most of the chapters, together with a list of references and a list of defining symbols used. A book suitable for a formal undergraduate engineering course, such as this one, emphasizes the rapid growth of rocketry from a curiosity into what is now a multibillion-dollar government investment.

Following is a brief outline of the content of each chapter: (1) Classification and definitions; accepted terminology; orders of magnitude involved; the momentum principle; some measures of performance. (2) History, up to World War II developments in Germany (e.g., V-2) and, in the United States, at the CalTech. Jet Propulsion Laboratory (JATO units, Wac Corporal). These developments supply much of the material for the entire book. (3) Relations between primary thermodynamic and flow parameters in nozzle theory. (4) Thermochemical aspects of motor operation; characteristics of several propellant combinations. (5) Relative merits of the most common liquid-propellant combinations are discussed. (6) Liquid-motor design considerations such as combustion-chamber volume, cooling, materials, loads and stresses, vibrations, injectors, motor starting and mounting. At the end of the chapter a sample rocket-motor design calculation is given which covers eight pages. (7) Pumps, plumbing, and valves required for a liquid-propellant feed system with special attention to the V-2 system. (8) Factors affecting flight performance; comparison with other means of aircraft propulsion; the velocities and energies required for space travel. (9) A description of test procedures, including safety precautions. (10) Fifteen pages devoted to solid-propellant rockets.

Robert M. Stewart, USA

Soil Mechanics, Seepage

(See also Rev. 3390)

3580. Wagner, A. A., Shear characteristics of remolded earth materials, "Triaxial testing soils bitum. mixtures," *ASTM Spec. tech. Publ.* no. 106, 192–224, 1951. $3.50.

Triaxial test results at constant lateral pressure with no drainage are presented for sand, sand-clay, and clay compacted to different densities at several moisture contents. Graphs show volume change, pore pressure, principal stress ratio, effective lateral pressure, and deviator stress at various axial strains. Mohr's stress circles are drawn for effective stresses at maximum principal stress ratio which is taken as the criterion of failure. Cohesion and friction are determined for linear envelopes, and their variation with moisture, density, and soil is discussed.

While the criterion of failure may be questioned, the data are valuable reference material. E. S. Barber, USA

3581. Kézdi, Á., Some problems on stress distribution in soil (in German), *Acta Techn. Hung., Budapest* **2**, 2/4, 371–389, 1952.

Author, following Mindlin [*Physics* **7**, 195, 1936], derives expressions for the stresses in an isotropic elastic solid due to a vertical point load and uniformly loaded circular area at any depth below the surface of the solid. Results show that, at a depth exceeding about twice the diameter of the circle, the vertical stress is practically one half of that due to a surface load on semi-infinite solid. Expressions are also derived for the vertical stress due to a uniform or linearly varying shearing stress applied to the surface of a semi-infinite solid. Practical consequences of the calculations are to be given in a subsequent paper. G. G. Meyerhof, England

3582. Arnold, M., The calculation of the coefficient of consolidation of a soil from experimental results, *Trans. S. African Instn. civ. Engrs.* **2,** 2, 47–60, Feb. 1952.

Author reviews methods for computation of coefficient of consolidation, including those of Taylor, Casagrande, Naylor, and Doran. He presents a simplification of the latter method and a new numerical method useful for rapid check of other methods. Methods are discussed as to their relative merit, and illustrations of their use are included. John C. Geyer, USA

3583. Endersby, V. A., The history and theory of triaxial testing, and the preparation of realistic test specimens, "Triaxial testing soils bitum. mixtures," *ASTM Spec. tech. Publ.* no. 106, 5–20, 1951. $3.50.

Author points out the important role played by triaxial tests in the definition of the bearing capacity of asphaltic road surfacing. As is known, the shearing resistance of materials is composed of frictional resistance and cohesion. Whereas the former increases with the load, the latter remains fairly constant at its initial value. As one proceeds from finer-grained materials to coarser, the role of internal friction tends to increase and that of cohesion to decrease. The state of stress is represented by the well-known Mohr circles and by its tangenting "envelopes." While the envelopes are grades in *linear plastic* materials, recent research work has shown that either the value of cohesion or that of internal friction may vary with loading or temperature conditions in many materials, such as bituminous paving mixtures. Hveem (Calif.) has shown this in his "stabilometer" (a triaxial testing device affording horizontal support by surrounding water), and Nijboer (Holland) approached the problem analytically.

According to author's view, there are four questions regarding the triaxial test which need further investigation: (1) What is the most acceptable interpretation for use by the routine testing engineer? (2) What is the effect of low height-diameter ratio prevalent in the field under road-loading conditions? (3) What is the real meaning of the intercept which denotes static or initial resistance in the Mohr diagram? (Cohesion.) (4) What is the proper method for compacting samples?

He concludes that the routine testing engineer must be supplied with graphs; that a uniform method of triaxial testing should be given to him, since it furnishes reliable results regarding the bearing capacity of pavement layers; and that a uniform way of making test specimens should be prescribed.

In order to accomplish this, a special expert committee was set up, which stated at once the decisive influence of the compacting method of samples. It must not be overlooked that the pavement is actually compacted by rolling, whereas test specimens are compacted either by static or by impact loadings. The different methods of compaction give entirely different results. Several compaction machines were, therefore, developed which are based mostly on the principle of kneading. According to the various tests, this way of compaction most nearly approaches rolling or traffic in general. Ch. Széchy, Hungary

3584. Polubarinova-Kochina, P. Ya., On the theory of unsteady flow in a multilayered medium (in Russian), *Prikl. Mat. Mekh.* **15,** 4, 511–514, July-Aug. 1951.

Paper deals with filtration in two horizontal layers superimposed upon an impervious medium. Porosity and filtration coefficients are constant within each layer. Author first derives formula for h, the height of the surface of water table, when flow is steady and parallel to axis Ox. Then she shows that the velocity potential Φ satisfies $\partial\Phi/\partial t = a^2\nabla^2\Phi$, where a is taken as constant, though it actually depends upon h. She returns to the special case for which $\Phi = \Phi(x, t)$, asks that the water surface be horizontal initially and that it remain within the upper layer, and solves for Φ. Ultimately she finds $h(x, t)$. The sixteen errors detected in the four pages of the article were annoying, to say the least. One of them was repeated three times, and the last formula alone contained three errors. R. E. Gaskell, USA

3585. Carlson, H., Calculation of depth of thaw in frozen ground, Frost action in soils, Symp., Nat. Res. Counc., Highway Res. Bd., spec. Rep. no. 2, 192–223, 1952. $3.75.

Aim of paper is "to present the development of a method of computation based on theory, laboratory experiments, and field observations which will enable the engineer to determine, with reasonable accuracy, depth of thaw in frozen ground under natural or artificial surfaces or structures where permafrost is encountered"—especially in connection with construction of airfields. Survey of theoretical formulas and experimental data (pertaining mainly to thermal properties of soils and temperatures of soil and air) are presented. Special attention is paid to connection between air and surface temperatures. Computed depths of thaw are in good agreement with observed depths. Depth of freezing in thawed ground can also be computed.

D. A. de Vries, Holland

3586. Skempton, A. W., and Northey, R. D., The sensitivity of clays, *Géotechnique, Lond.* **3,** 1, 30–53, Mar. 1952.

Many clays lose some of their strength when subjected to disturbance by sampling, pile driving, or vibration. The factors influencing sensitivity (undisturbed/remolded shear strength) of clays are discussed. Experimental work indicates that thixotropy can account for low and medium sensitivity but not for high sensitivity, which can be explained by leaching of salt from clay, causing a drop in the remolded strength.

G. G. Meyerhof, England

3587. Croney, D., The movement and distribution of water in soils, *Géotechnique, Lond.* **3,** 1, 1–16, Mar. 1952.

Large seasonal variations occur in the moisture condition of soils located above the water table close to the ground surface. Such changes are important because they exert an appreciable influence on the mechanical properties of these soils. Fundamental factors which lead to moisture movements within a soil mass are summarized in detail. From these considerations, the concept of "moisture-suction" or the soil-suction characteristics are developed. Variations of the conventional soil-moisture content (i.e., the water present expressed as a percentage of the dry weight of the soil) are inadequate to explain the soil-moisture movements which have been observed experimentally. However, theories dependent on suction characteristics have been used with some success. Soil suction is defined as "the difference between the pressure of the water in the sample and atmospheric pressure"; also by definition, the suction of a sample in equilibrium with free water is zero. As moisture is removed from the sample during a drying process, the soil suction rises rapidly. The final value of this suction is dependent on the relative humidity of the atmosphere contacting the specimen. A laboratory technique was developed to evaluate suction characteristics of soils. Some experimental confirmation of the relationships involved has been obtained, and field investigations are currently in progress; this work is particularly concerned with methods of estimating moisture changes which occur when large areas of soil are covered with road or airfield pavements. Thomas L. Speer, USA

3588. Baker, R. F., Determining corrective action for highway landslide problems, *Nat. Res. Counc. Highway Res. Bd. Bull.* 49, 1–27, 1952.

Illustrating the frequency of landslides on highways, author

deals with the problem of how to find the most economical treatment of existing landslides. The lack of systematic classification of landslide phenomena in relation to this action is emphasized. Rules for field investigations are given. Using current "slices" method of stability analysis, author attempts to approach the reality by using both the zero friction-angle analysis and classical analysis (with friction angle 10° in example).

Author's systematic classification of corrective measures accompanied by critical comments is very useful. Three groups of methods are outlined: elimination methods, retaining devices, and direct rebalance of the ratio between resistance and shearing forces.

Reviewer believes that using classification related to structure and cause of landslides as a basis (such as Terzaghi does), and introducing corresponding corrective measures, the article would be still more instructive. See advanced papers by Maslov ("Prikladnaya mekhanika gruntov," 1949).

V. Mencl, Czechoslovakia

3589. Rogers, F. T., Jr., Schilberg, L. E., and Morrison, H. L., Convection currents in porous media. IV. Remarks on the theory, *J. appl. Phys.* **22,** 12, 1476–1479, Dec. 1951.

Differential equations for critical stability of a fluid in a porous medium and heated from below are solved by the Picard method. A single formula is obtained for the thermal environment at critical stability, apparently valid over a wide range of conditions, which allows for temperature dependence of viscosity and nonlinear temperature distributions. New experiments are reported in which initial convection has been detected by visual, thermal, and radioactive tracer means. The experimental mean thermal gradients for critical stability by the above methods deviated from the new solution, on the average, by 150%, 32%, and 11%, respectively.

From authors' summary by C. F. Bonilla, USA

Micromeritics

3590. Bostock, W., A sedimentation balance for particle size analysis in the sub-sieve range, *J. sci. Instrum.* **29,** 7, 209–211, July 1952.

The method of Oden is used for the analysis of particle size distribution for the size range 75-5, the settling quantities being measured by a torsion balance weighing under water. The simplicity and speed of the method are stressed, the time involved being little longer than that taken for the particles to settle.

The accuracy cannot be assessed as no comparison is made with other methods. G. H. Lean, England

Geophysics, Meteorology, Oceanography

(See also Rev. 3545)

3591. Stümke, H., Rational treatment of convection in the approximate calculation of weather development (in German), *Meteor. Rdsch.* **5,** 3/4, 45–47, Mar./Apr. 1952.

The hypothesis of Stümke's approximation theory provides, as its main condition, a specification of the thermodynamic progress of a uniform convection process. The mathematical form of this condition permits the indication of the rearrangement of air masses as a function of the mass-dipoles through the description of the readily calculable source-and-sink method. In the case of large-scale uniform air masses, the variable source-and-sink distribution will be replaced by a uniform distribution. The loss of the impulse of the ascending mass is considered by the formulation of the corresponding reacting force in the equations of motion through the vertical gradient of the horizontal wind velocity.

From author's summary by L. Machta, USA

3592. Sato, T., Dynamics of the jet stream, *Pap. Meteor. Geophys.* **2,** 2, 132–149, June 1951.

Author considers the stationary motion in an autobarotropic atmosphere, assuming the variables independent of longitude, and defines a front as a surface of discontinuity between two such air masses. The tropopause is also defined as a front. The different properties of the fronts are deduced from the equations of conservation of absolute angular momentum, vorticity, and energy. Within each air mass, the zonal wind distribution is determined by the convective motion in the meridional plane. Three such air masses are supposed to meet at the triple point, i.e., the point of intersection of the polar front and the tropopause, such that strong westerlies and easterlies exist to the south-and-north-side of the polar front. This will produce strong mixing which will diminish the maximum wind velocity and shift the jet stream of westerlies southward. An explanation of the general circulation is also suggested. H.-L. Kuo, USA

3593. Ogura, Y., Relations between the length of time under analysis and the statistical quantities of the atmospheric turbulence, *J. meteor. Soc. Japan.* **30,** 3, 103–111, Mar. 1952.

Because the spectrum of turbulence in the atmosphere contains eddies whose period is comparable with the time interval over which an anemometer record is analyzed, no complete representation of the large end of the spectrum can be obtained from measurements. One is frustrated at the other end because a more sensitive instrument always detects yet smaller eddies. Author investigates what useful ideas the statistical theory has to offer about atmospheric turbulence, but one's confidence in his use of observations is shaken by: "In the actual case mentioned above, the representative time scales are 46 and 25 sec for the data of 5 minutes, and those for 1 minute are 2.4, 6.6, and 13 sec. The mean value of t_0 for the former case is 3.5 sec and that for the latter is 7.3. Therefore, the former value is five times as large as the latter, as expected from theoretical considerations." After this, he could make any theory plausible.

R. S. Scorer, England

3594. Pélegrin, M., Measurement of atmospheric turbulence (in French), *C. R. Acad. Sci. Paris* **235,** 1, 19–21, July 1952.

Paper describes very promising technique of measuring atmospheric gusts as functions of time and locality by means of a free balloon upon which hot wire sensors are mounted. Detailed results and analyses of same in relation to other meteorological quantities are not yet presented, nor are the results of statistical computations from the data (author's abstract is misleading on this point). Joanne Starr Malkus, USA

3595. Carr, J. H., and Stelzriede, M. E., Diffraction of water waves by breakwaters, Heat Transfer Fluid Mech. Inst., Stanford Univ., 5–16, 1951.

Two theoretical methods deal with the diffraction of water waves through a gap in a straight breakwater. The Penney-Price method (based on Sommerfeld) is suitable for gap widths exceeding two wave lengths, and has been verified experimentally by Putnam and Arthur, and by Blue and Johnson. The Morse-Rubenstein method is adapted to gap widths from zero to three wave lengths. The authors' experimental work, dealing for the first time with narrow gaps and oblique (as well as normal) incidence, is in sufficiently close agreement with the latter theory to

justify its engineering application. Experimental results are also given for two breakwater configurations not yet dealt with theoretically—symmetrically converging and right-angle breakwater. When the two arms of the breakwater form angles of 180° to 60° (measured through the harbor), the theory still applies fairly well. For smaller angles, the wave amplitude along the arms is higher than given by theory.

Walter H. Munk, USA

3596. Syōno, S., On the motion of a vortex in a nonuniform pressure field, *Pap. Meteor. Geophys.* **2, 2,** 117–128, June 1951.

Author derives equation of motion for a unit slice of a circular vortex from the Eulerian equations by splitting up the motion into that of the vortex as a whole and that relative to its center. Vertical motion and viscosity are neglected; the density is assumed to be constant. Solutions are given for stationary as well as nonstationary pressure fields. Analysis of solutions shows that they are composed of four different types of motion—a gradient wind component, a cycloidal motion, a zonally accelerated motion, and an oscillatory motion. These are discussed in regard to their origin and significance. Horst Merbt, Sweden

3597. Cook, G. W., Sensitive vertical displacement seismometer, *David W. Taylor Mod. Basin Rep.* 814, 45 pp., Apr. 1952.

Author describes an original seismometer for vertical displacement. A seismic arm which is attached to a torque wheel with two flexure hinges is supported with two cantilever springs of beryllium copper. The restitutive force is controlled by electrostatic force which is produced with an electrostatic-force generator. The position of the arm can be adjusted electromagnetically with a permanent magnet mounted on the arm and differential electromagnets. The damping is also controlled by electrostatic force which relates to the output voltage. With a differential capacitor mounted at the end of the arm, the displacement is detected and converted into the output voltage which is introduced to a recorder through an amplifier. Thus, one can change period of free oscillation, damping, and sensitivity in a wide range. Electronic techniques are skilfully used for these controlling systems. With this instrument, displacement of 0.05 micron is able to be magnified to as much as 2 cm on the recording tape. Author studies mathematically the motional behavior of the instrument as well as its electrical analogy. Careful construction and adjustment will be needed for practical use of this seismometer. Tsuneji Rikitake, Japan

3598. Nothmann, E., A recording raingauge, *J. sci. Instrum.* **29, 7,** 229–230, July 1952.

An instrument is described in the design of which special care was taken to avoid the incorporation of sources of principal errors. It consists of two independent systems, one a self-balancing weighing beam for recording rainfall, and the other a float chamber for automatic empyting, this being suspended on the load-side of the weighing beam and acting as rainwater receiver. Extensive tests of a prototype model have shown it to be accurate to more than 1% of its range. It is self-cleaning during each emptying process. From author's summary

3599. Vincent, R. S., Apparatus for the determination of moisture in samples of air, *J. sci. Instrum.* **29, 5,** 155–157, May 1952.

A sample of air, 85 cc or more in volume, is taken into an evacuated flask which is subsequently connected to the measuring apparatus, and the water vapor pressure is measured manometrically by absorption in phosphorus pentoxide. The success of the method depends on freezing the moisture temporarily on the inner surface of the flask, thus permitting almost complete separation of the air from the moisture to be measured.

From author's summary

3600. Hadady, R. E., Moisture measurement, *Instruments* **25, 5,** 600–602, May 1952.

The factors of greatest importance in moisture measurement are dew-point range, accuracy, temperature range, speed of response, simplicity of operation, and relative price. Author compares various instrumental methods.

From author's summary

3601. Wexler, A., and Daniels, R. D., Jr., Pressure-humidity apparatus, *J. Res. nat. Bur. Stands.* **48, 4,** 269–274, Apr. 1952.

An apparatus for producing atmospheres of known relative humidity, based on the "two-pressure principle," is described. It has a working space (test chamber) of 1 cu ft, in which the relative humidity may be varied and controlled from 10 to 98%, the temperature from −40 to +40 C, the air flow up to 150 liters per minute, and the test-chamber pressure from 1/2 to 2 atm. The humidity in the test chamber may be set and maintained to an accuracy of at least 1/2 to 1% relative humidity.

From authors' summary

Lubrication; Bearings; Wear

(See also Rev. 3407)

3602. Macks, E. F., Nemeth, Z. N., and Anderson, W. J., Operating characteristics of cylindrical roller bearings at high speeds, *Trans. ASME* **74, 5,** 705–710, July 1952.

The high-speed aspect of bearings in general has been discussed so as to establish a perspective of where the problem stands with respect to present and future service requirements. The significance of the bearing-operating temperature is discusssed with regard to bearing-operating limitations. The extent of the effects of speed, load, oil flow, oil-inlet temperature, oil-inlet velocity, and oil viscosity upon the bearing inner- and outer-race temperatures is shown. It is shown that roller slip occurred in high-speed roller bearings, and that there is a fundamental difference in the operating characteristics of certain types of high-speed bearings heretofore considered to be essentially equivalent. Oil-inlet distribution also is found to be a significant factor regarding the control of bearing-operating temperature. The test-rig results as well as the turbojet-engine data have been generalized by means of dimensional analysis to allow the designer to predict the bearing-temperature rise from a single curve, regardless of whether bearing speed, bearing load, oil flow, oil-inlet temperature, oil-inlet velocity, or oil-inlet viscosity varies over wide ranges.

W. Kochanowski, Germany

Marine Engineering Problems

(See also Rev. 3462)

3603. Gebers, F., The paddle wheel in model test [Das Schaufelrad im Modellversuch]. With an appendix by F. Horn (in German), Wien, Springer-Verlag, 1952, 61 pp., 59 figs., DM 7.20.

Model tests were made with two types of paddle wheels, one designed for light loading, the other for towing. Scale was 1/10, also 1/5 for the towing model. Investigation covered the following variations—number of blades (8 and 4), width and height of the

blades, draught of the wheel, water depth. For each case the complete model results are represented, so that the book gives extensive and systematic material in this field, including some considerations on scale effect. Further, several examples of practical design are given. Comparing the efficiencies from the tests with the theoretically possible maximum, author concludes that future improvements of a properly designed wheel cannot be expected. In the appendix, F. Horn considers the results on a basis of the laws of similitude, which is not done systematically in Gebers' representation and discussion. On this basis, Horn arrives at a condensation of the model results from which a simple and clear method of design follows. H. W. Lerbs, USA

3604. Denny, M. E., B.S.R.A. resistance experiments on the "Lucy Ashton," *Inter. Conf. nav. Arch. mar. Engrs.*, 40–53, 1951.

Full-scale measurements of ship hull resistance are rare, although they are extremely valuable in determining the reliability of full-scale predictions from model tests. They are needed to verify the several methods of ship skin-friction calculation. Hence, the *Lucy Ashton* tests promise to be a classic in the field, in that they involve a 190-ft ship at Reynolds number up to 375×10^6. This work is also of interest due to the novel use of jet engines for propulsion, thus eliminating the possibility of extraneous effects from the towing vessel.

This first of a series of papers, besides outlining the program, presents the test and instrumentation details. Such items as the methods of preparation of the steel hull of this 60-year old former paddle wheeler, the thrust cells used for measuring the nearly six-ton thrust, the method of clocking the speed, and the surface-roughness measuring instruments are thoroughly presented.

The results of a preliminary analysis of the tests indicate that fairing the longitudinal seams in the steel plating reduced the total resistance 3%, and the use of a bituminous aluminum paint in place of red oxide reduced it another $3\frac{1}{2}$%.

J. M. Robertson, USA

3605. Libro, N., Ship geometry and mathematical determination of the shape (in Swedish), *Tekn. Tidskr.* **82,** 15, 341–348, Apr. 1952.

Author has taken as example a 5.5-meter international sailing yacht. To get fairly simple mathematical curves, the surface is divided into three parts—the surface of the hull proper, the fillet surface, and the keel surface, the second one giving the transition between hull and keel.

For the hull surface, longitudinal curves are drawn for the lowest points where the center-line plane cuts the frame sections, for the maximum width of the frame sections, for the vertical position of these latter points, and for a suitable intermediate diagonal. These parameter curves are given mathematical form by means of the interpolation formula.

$$v = A_1(u - u_1) + A_2(u - u_1)(u - u_2) + \ldots + A_n(u - u_1)(u - u_2)\ldots(u - u_n)$$

for which the constants A are determined by means of a chosen number of points on the curves. Each frame section is then adapted to a second-degree curve with equation $Au^2 + v^2 + 2Buv + 2Cu + 2Dv = 0$, of which the constants A, B, C, D are determined by means of the three points where the parameter curves cut the section, plus the inclination of the tangent to the section at its lower point and the fact that the tangent at the point of maximum width will be vertical.

Computation tables have been given for some sections of the example. Georg Vedeler, Norway

3606. Szebehely, V. G., Hydrodynamics of slamming of ships, *David W. Taylor Mod. Basin Rep.* 823, 31 pp., July 1952.

The impulsive forces on the bottom of a ship during an impact are analyzed. Considering a V-wedge bottom, the differential equation for the motion during impact is formulated. Effects of added mass and piled-up water are included. The bottom shape which would produce a constant force is calculated. Good agreement between theory and experiment is shown in the range of increasing impact force. Suggestions for further research are given.

G. V. R. Rao, India

3607. Bunyan, T. W., A study of the cause of some rudder failures, *N.E. Cst. Instn. Engrs. Shipb. Trans.* **68,** 7, 313–330, May/June 1952.

A study of the vibration characteristics of the ship rudder (torsional and flexural) is made. Calculations are reasonably well supported by tests. The effects found can account for some failures in the rudder and its attachment; in addition, a new explanation for transverse vibrations of the hull is found. It is shown that the propeller slipstream may cause considerable exciting forces. Author considers his investigation as only an introduction to the study of the phenomena involved.

G. P. Weinblum, Germany

Please Note

The Subject and Author Indexes to APPLIED MECHANICS REVIEWS, Vol. 5, January-December, 1952, are to be published in separate pamphlet form and will be mailed together with the January, 1953, issue of APPLIED MECHANICS REVIEWS.

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